Power and The Engineer

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THERE are several factors that enter into the successful operation of steam power plants, and not the least of these is the fireman.

There may be steam-jacketed cylinders with infinitesimal clearances and valves, and pistons as tight as the proverbial bottle.

Contraflo condensers equipped with air pumps of miraculous efficiency may produce vacuums rivaling the comet's tail in tenuity.

There may be boilers and economizers so correctly proportioned that the escape of a single heat unit is almost as improbable as the discovery of an honest professional politician.

There may be water-weighing apparatus so accurately adjusted that it could on a pinch be used for a barometer, and the walls may be decorated with flue-gas analyzing apparatus that resembles a chemical laboratory in its complicated completeness.

There may be continuous and intermittent steam-engine indicators, recording thermometers and pressure gages.

Superheaters may furnish steam so dry that its own weight of water will scarcely moisten it, and besides there may be a chief engineer worth a congressman's salary.

All these things and countless others that go to make the finished modern power plant may be there and under competent supervision.

But if the athletic, intelligent, ridiculously underpaid worker who is capable of delivering the largest percentage of the potential energy in the coal to the rim of the flywheel of the engine—the real fireman—is not there, all the rest is "sounding brass."

Coal per kilowatt-hour, coal per car-mile, and pounds of water per pound of coal are of frequent enough occurrence in power-plant reports to show that a part of the expense of power-plant operation is measured in coal units, and the man who handles these units is the most important factor in the steam plant.

The most highly economical engines in the world will not deliver low-priced power if supplied with costly steam, but a very ordinary equipment will do fairly well if the man behind the shovel knows his business.

If he knows that a heavy draft needs a thick fire, if he realizes the difference between heavy firing at long intervals and light firing at short ones, if he is aware that fresh coal should only be spread on an incandescent fuel bed, he knows enough of the other details of economical steam making to be the most valuable man about the plant if he so desires.

If such a desire exists, and the man feels the responsibility of his position and lives up to it, recognition in terms of dollars and cents should be immediate and commensurate with the service rendered.

Intelligent power-plant managers appreciate the value of labor-saving and labor-displacing appliances, and as much as possible the human element is being eliminated from all power-plant problems.

But as long as the burning of coal for power production continues, just so long will the human element be indispensable in the boiler room, and the best is none too good.

"Common good has common price; exceeding good, exceeding."

Dimensions of Steam Turbines

By Charles A. Edmonds

The preliminary calculations, forming the basis of all steam turbine design, are discussed and current practice in dimensioning the various parts is cited.

In designing a steam turbine, the first and most essential step is to estimate the highest suitable speed of rotation in order that the turbine may be made as small as possible for the required efficiency. While there is now no great difficulty in accurately determining the proportions of turbines to insure certain results, with ample confidence to enable a stiff guarantee being made both for speed and economy, the principal dimensions involve considerable calculation.

Although Fig. 2 illustrates a Parsons' marine type of turbine, the method of calculation of the proper dimensions is carried out in exactly the same manner as for a land turbine, except that the most economical speed of the propeller has to be considered first of all. The Parsons' marine type of turbine differs from the land type in that it has no dummy cylinders to counteract the end thrust of the shaft, caused by the expansion of the steam issuing from each set of blades. These dummy cylinders *P P P*, Fig. 1, are not needed in the marine turbine because the end thrust of the turbine is taken up by the thrust of the propeller which is on the same shaft.

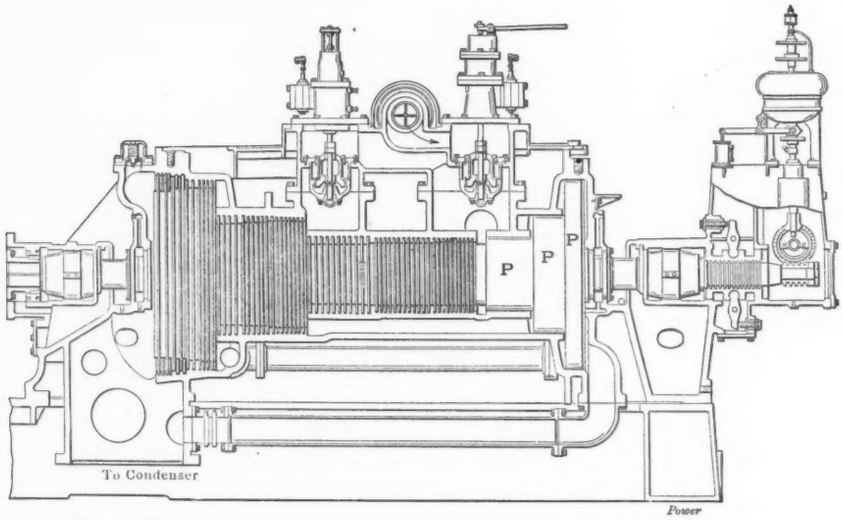


FIG. 1. LONGITUDINAL SECTION THROUGH TYPICAL PARSONS TURBINE

Roughly, the weight of turbines will vary inversely as the square of the revolutions, while the economy will remain almost constant if the turbines are designed for the same internal conditions.

The laws governing the best theoretical velocity of the steam and the blades in impulse turbines are similar to those for water turbines, but in practice some modification is necessary, and the best ratio of blade speed and steam speed is still a matter of opinion. The ideal condition for impulse turbines occurs when the peripheral velocity of the buckets is one-half that of the jet, or in reaction turbines when it is equal to it.

Parsons' turbines have been built with V_t, Fig. 3, varying from 0.25 to 0.85 of V_s, where V_t represents blade velocity at mean diameter, and V_s the steam speed across the row in question. A very usual ratio for large units in electrical work has been

$$\frac{V_t}{V_s} = 0.6$$

These ratios require very careful calculation. The steam consumption must be accurately known in order to proportion them correctly throughout the turbine, and the necessity of having the same area of openings in so many rows while the steam volume increases so rapidly adds to the difficulty of close calculation.

The potential energy of the steam, corresponding to the "head" in water turbines, can easily be calculated for given pressure differences.

The well known expression connecting energy and velocity is

$$E = \frac{W V^2}{2g}$$

where

E = Energy,
W = Weight,
V = Velocity,
g = Acceleration due to gravity.

Taking the weight W as one pound of steam, expressing the velocity V and the acceleration due to gravity g in feet per second, and the energy E in foot-pounds, $g = 32.16$ and $E = 778 \times B.t.u.$ utilized. Then,

$$V^2 = 2 \times 32.16 \times 778 \times B.t.u.$$

and

$$V = \sqrt{50{,}040.96\ B.t.u.} = 223.81 \sqrt{B.t.u.}$$

It is obvious that the speed ratio between jet and vane must affect the number of stages and that with a given turbine velocity the greater the ratio of V_t to V_s the greater will be the required number of rows. To obtain a small value for V_s necessary to produce a large value for $\frac{V_t}{V_s}$, a small pressure drop per row is necessary.

The mean diameter is a dimension capable of wide variation without affecting the efficiency, provided that the number of rows is correct.

Calling this mean diameter in inches d, the blade velocity in feet per second will be

$$V_t = \frac{d \times \pi \times r.p.m.}{12 \times 60}$$

and assuming a blade velocity from experience the diameter can be determined.

$$d = \frac{12 \times 60 \times V_t}{\pi \times r.p.m.} = \frac{229 \times V_t}{r.p.m.}$$

HENCE: *To find the mean diameter of the rows of buckets, multiply the bucket velocity in feet per second by 229 and divide by the revolutions per minute.*

To arrive at the corresponding number of rows, the revolutions being given, the ratio of V_t to V_s must be settled, from which the steam speed can be obtained. It is a convenient assumption at the beginning of any design to consider the turbine as parallel throughout and of constant efficiency, and to design on this basis. The number of rows N on one diameter can be found by work-

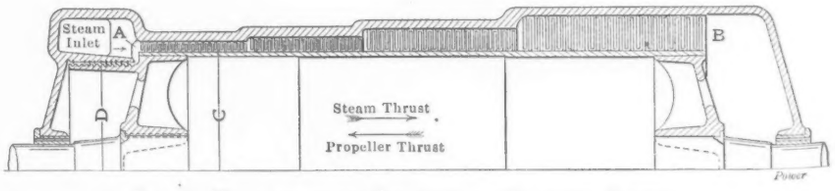


FIG. 2. HIGH-PRESSURE CYLINDER OF PARSONS TURBINE

ing out the British thermal units necessary to give a certain steam speed at each row; see Fig. 4. The available energy divided by the energy it is desired to abstract at each row will give the number of rows required. This result may be arrived at by various ways, but the principle involved is the same in each case. Numerous empirical coefficients for approximating steam speeds and the corresponding number of rows are obtainable from experience. To put all the rows on one diameter would involve an excessive length of turbine and also inconvenient blade hights. It is, therefore, usual to divide the rotor into three or more stages, which has the advantage of shortening the turbine and reducing the number of rows. If $\frac{1}{n}$ = the fraction of power developed in the first cylinder or barrel, $\frac{N}{n}$ = the number of rows in the first barrel and with the change of diameter and increase of blade velocity in the succeeding stages,

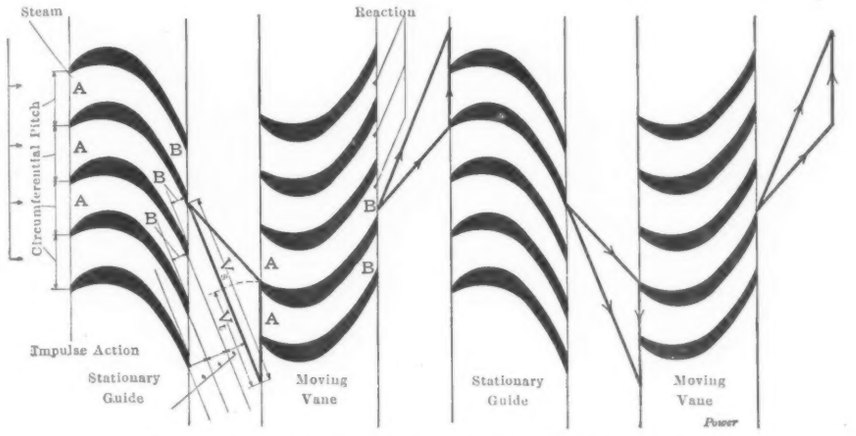


FIG. 3. ACTION OF THE STEAM IN THE PARSONS TURBINE

Vt = Blade velocity at mean diameter.
Vs = Steam speed due to expansion between A and B.

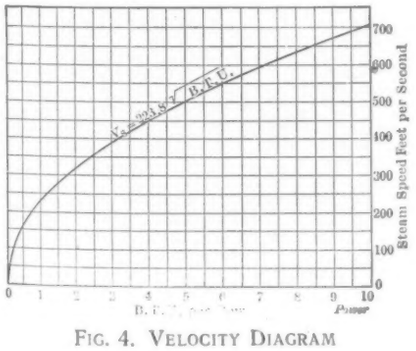


FIG. 4. VELOCITY DIAGRAM

the number of rows on other barrels is so altered as to keep, for equal powers and efficiencies,

$$(Blade\ Vel.)^2 \times No.\ of\ Rows = Constant$$

The vane speeds adopted in practice vary considerably; for some time 100 feet per second was regarded as a standard for the first row, and I think the Westinghouse Company, at Pittsburg, was the first to make a radical departure in this respect and adopt higher speeds. The maximum vane speed used for Parsons' blading is, as far as the author is aware, about 375 feet per second in the low-pressure blades, and 170 in the high-pressure blades for turbines driving electric generators. To some extent blade speed is governed by blade hight. The speed should be so modified that this may be at least 3 per cent. of the mean diameter to reduce the proportion of clearance losses. Leakage over the tips of the blades is perhaps not so detrimental on account of actual loss as in its superheating effect on the steam between the row past which it leaks and the last row, because the reheating effect upsets calculations regarding openings by increasing the steam volume and thereby effects the fluid efficiency. This leakage over the tips must be taken into account in designing reaction turbines. Temperature and diameter influence the clearance, and the stiffer the cylinder is made to resist distortion due to heat, the less may be the clearance. A clearance diagram based upon measurements of a large number of machines is given in Fig. 5.

TABLE 1. VARIOUS VANE SPEEDS.

Normal Output of Turbine.	Peripheralvane Speed		No. of Rows.	Revolutions per Minute.
	First Expansion.	Last Expansion.		
5000 kw...	135	330	70	750
3500 kw...	138	280	75	1200
2500 kw...	125	300	84	1360
1500 kw...	125	360	72	1500
1000 kw...	125	250	80	1800
750 kw...	125	260	77	2000
500 kw...	120	285	60	3000
250 kw...	100	210	72	3000
75 kw...	100	200	48	4000

Replying to the discussion on his paper before the Institute of Naval Architects in 1903, Mr. Parsons said that, "for all practical purposes, while the steam is traversing each set of blades, it behaves like an incompressible fluid, just as water would do, the expansion being very small at each set. The frictional losses and the eddy-making losses are practically identical, within small limits, with that of water; and the actual forces are in proportion to the density of the medium. In the turbine blades themselves, the efficiency is between 70 and 80 per cent."

This hydraulic analogy enables us to calculate the number of stages required in a different manner. The "equivalent head" due to the steam pressure, together with that at each row necessary to give the required velocity, may be found, and from these both the number of stages and the coefficient of expansion at each stage may be worked out.

In all types of turbines, Parsons, Rateau, Curtis, etc., a certain ratio must be maintained between the blade velocity and steam velocity, and as steam acquires very high velocities by expansion, the blade velocity must be maintained either by a high rotary speed or by large diameters, or both. As the weight increases very rapidly with the diameter, and especially with the reduction in rotative speed, it is preferable to increase, if possible, the revolutions or the number of stages rather than the diameter. This should be done in cases where the weight increases more rapidly in inverse proportion to the rotative speed and the diameter, as in the Rateau or Zoelly types.

Having obtained the number of rows and the diameter, the blading arrangement can be worked out in detail. The hight of blade depends upon the volume of the steam and the speed at which it is to flow; also upon the ratio of the area of exit openings between the blades to that of the annulus between spindle and cylinder, which is about one-third in normal blades. The necessary clear area for the steam to pass through being equal to volume divided by velocity, and knowing this annular factor, say 3, for a ratio of one-third (or 2 for ½, etc.) then

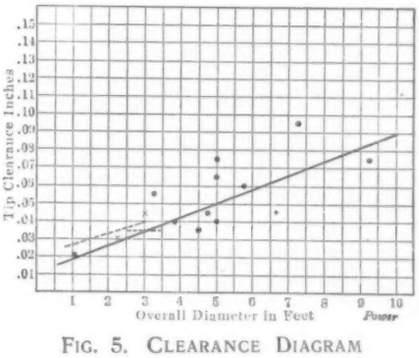


FIG. 5. CLEARANCE DIAGRAM

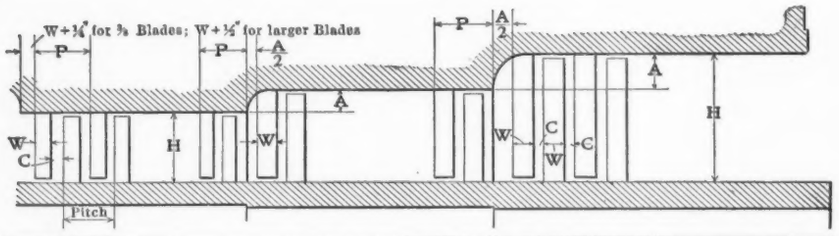
$$Hight\ of\ blade\ in\ inches = \frac{Clear\ area\ in\ square\ inches \times 3}{Mean\ circumference\ in\ inches}$$

The ratio of blade hight to mean diameter should not be less than 3 per cent., or more than 15 per cent., because in the former the percentage of leakage will be

excessive, and in the latter the bending moment and the radial divergence of the blades become too great. The width of blade, the shape of section adopted and the circumferential pitch, are standard considerations, and affect the factor 3, given above. It is not proposed to enlarge upon them in this paper. It may, however, be remarked that for $\frac{Vt}{Vs}$ greater than 0.6 the usual shape of Parsons' section, as shown in Fig. 2, should be modified to a somewhat different form of blade, with a sharper entrance edge. This section is not to be recommended, as, owing to the necessity of sufficiently strengthening the blade, the metal must be placed nearer the exit edge, thus increasing the angle between the face and the back of the exit edge of the blades, and giving an inferior shape of opening compared with that obtainable with a blade section adapted to ratios under 0.6.

In Table 2 can be found a list of approximate widths for a given hight, and axial spacing of the rows. While this must be kept down to reduce the length of drum, it must be sufficient to allow for some play in overhauling, and sufficient clearance can be allowed here without affecting the economy. The openings between the blades to allow for the passage of the steam are very important, and must be carefully designed. The actual volume of the steam, not the volume per pound, as found in steam tables, or the volume due to adiabatic expansion, but the exact volume per pound at any point along the turbine must be determined in order to arrive at the desired adjustment of velocities. It is extremely doubtful whether the present blading arrangements give the best results. Greater accuracy of calculation and consequently improved pressure distribution and efficiency seem likely to follow the use of a more mechanical blading construction.

TABLE 2. STANDARD BLADE DIMENSIONS



Height (H)	1"	2"	3"	4"	6"	8"	10"	12"	15"	18"	21"	24"	30"
Width (W)	⅜"	⅜"	⅜"	½"	½"	⅝"	⅝"	¾"	¾"	1"	1"	1⅛"	1¼"
Pitch (P)	1⅛"	1⅛"	1¼"	1⅝"	1¾"	2⅛"	2¼"	2½"	2⅝"	3⅛"	3¼"	3⅝"	4"
Axial Clearance (C)	3/16"	3/16"	¼"	5/16"	⅜"	7/16"	½"	½"	9/16"	9/16"	⅝"	11/16"	¾"

Power

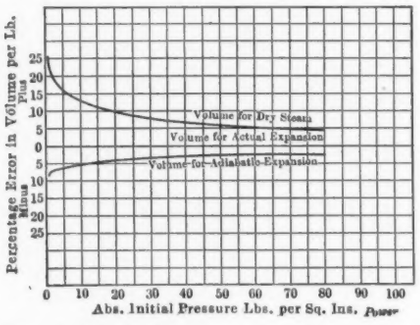


FIG. 6. ERROR DUE TO INCORRECT ESTIMATE OF STEAM CONDITIONS

For convenience in manufacturing, as well as to allow for the expansion of the steam, the blade hights are stepped up, but no rule exists for this. The blades might be of 1, or of 65 hights, provided the blade openings were correct. It is, however, convenient to step them, as in Fig. 2, say, in 8 steps of 8 rows each, or 4 steps of 16 rows; even 9 steps of 7 rows would do to avoid any great variation from the annular area factor 3, as shown above.

To obtain hights and areas, it is best to plot graphically, volumes, steam speeds and the clear areas required. The use of standard blade hights will then enable the number of stages and rows per stage to be determined, and wide differences can be made in any arrangement without materially affecting the economy. The best arrangement is largely a matter of convenience and experience.

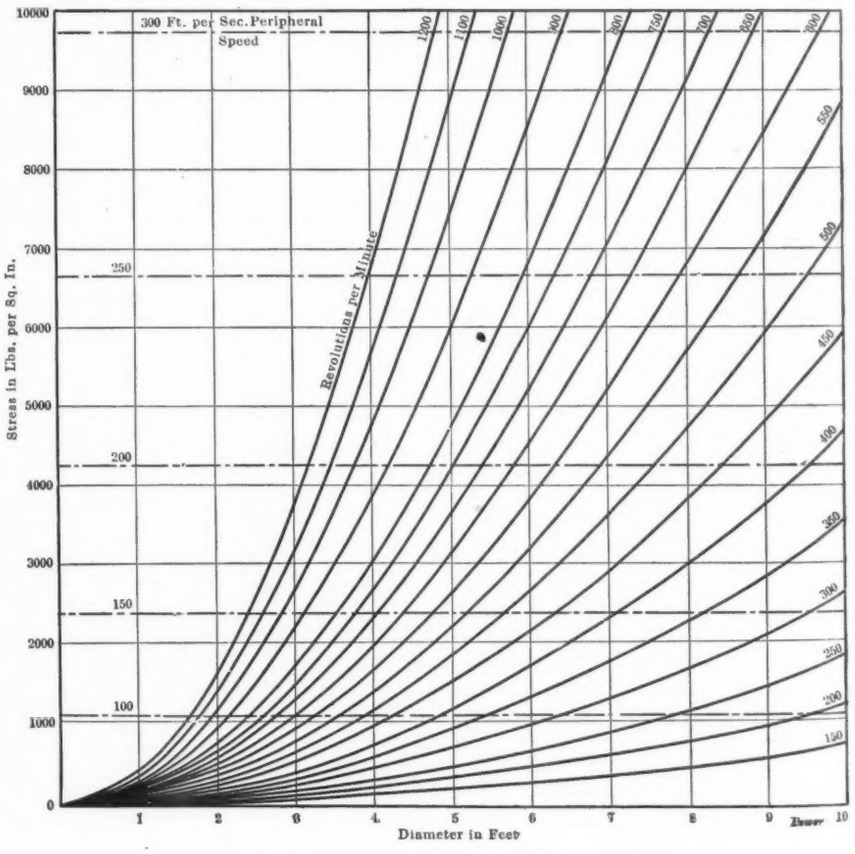


FIG. 7. STRESSES DUE TO VARIOUS SPEEDS

Fig. 6 shows the percentage of error involved in using either the dry volume, or that due to adiabatic expansion, compared with the correct volume corresponding to the actual expansion in a large turbine using dry saturated steam at the first row of blades and 27 inches vacuum. Attention must be paid to the effect of approximate adiabatic expansion and the consequent moisture in the steam.

The material of which blades are usually made is a mixture of cheap brass containing about 16 parts of copper and 3 parts of tin. Alloys containing zinc are extremely unreliable for high temperatures, but blades containing about

98 per cent. of copper have been found very satisfactory for use with high superheats. More recently a material containing about 80 per cent. of copper and 20 per cent. of nickel has been adopted, and this is undoubtedly the best blading material in existence. Steel blading, drawn in the same way as the usual brass section, has been used in the United States with fairly good results. The process of drawing turbine blades gives an extremely tough skin to the metal, not only increasing the tensile strength, but greatly decreasing the chances of erosion.

It seems probable that the usual calking piece now adopted will be discarded in favor of a machine-divided strip into which the blades may be fitted, and instead of the slotting, wiring, lacing and soldering process at the tip, a similar machine-divided shroud will be used, giving a far stronger construction, and enabling finer clearances and better workmanship to be obtained, at the same time considerably reducing the cost of manufacture and the risk of blade stripping.

The chief causes of the latter may be set down to bad workmanship in setting the blades, defective blade material, excessive cylinder distortion (this is probably the most fruitful cause, and is a serious one, being due to bad design), whipping of turbine spindles (which is also due to bad design, or bad balancing), wear of bearings (which is very remote), and the introduction of extraneous substances such as water or grit. In fact, blade stripping may be said to occur generally from preventable causes. Small vibrations of very high frequency occasionally set up an action in certain rows of responsive length and fatigue the blade material, causing the loss of blades without any fouling at all.

In turbines driving electric generators, where the end thrust must be eliminated by the use of balancing pistons, the spindle is in tension when the cylinder is balanced. The shafts between the turbine bearings and the drum must be made amply stiff, as well as strong enough, as any sag in the spindle will destroy the clearance. As will be seen from Fig. 7, the stresses due to centrifugal force are very low in the Parsons turbine, and except in occasional low-pressure barrels they do not exceed 7500 pounds per square inch, while at the high-pressure end they are usually under 2000.

The pressure on the bearings in a turbine is due only to the weight of the spindle. It may be taken from 80 to 90 pounds per square inch as long as the rubbing velocity does not exceed 30 feet per second. If it does, the pressure must be reduced so that the product of pressure and velocity does not exceed 2500 to 2700. In land work 50 pounds multiplied by 50 feet is very common. The friction heat of the bearings added to that due to conduction through the pedestals, necessitates the use of large oil coolers, and in the case of very high temperatures, of special kinds of oil. If possible, the bearing temperatures should not exceed 140 to 150 degrees Fahrenheit, though the writer has known of 190 degrees being used without trouble.

Space does not permit of more than passing reference to cylinders, but it would be difficult to exaggerate the importance of very careful design in this connection. Cylinders, with heavy flanges on the center line, distort in a very curious fashion when heated with their axes horizontal, and measurements taken of a hot cylinder on a surface plate with micrometer gages reveal some very remarkable facts. When working, the temperature along the cylinder falls from 400 to 100 degrees Fahrenheit in a distance of 6 or 8 feet, and unlike the reciprocating engine, this remains constant. The radial expansion is consequently more at one end than the other, while at any point along the turbine the tendency is to expand less at the flanges than at the top and bottom. For this reason ample clearance must be allowed; exactly what this will be when the spindle and cylinder are hot is hard to say, but it seems most likely that the total clearance area will differ but little from what it is when cold.

The longitudinal expansion when hot is often very marked, and in all turbines, necessitates provision for the resultant movement at one end.

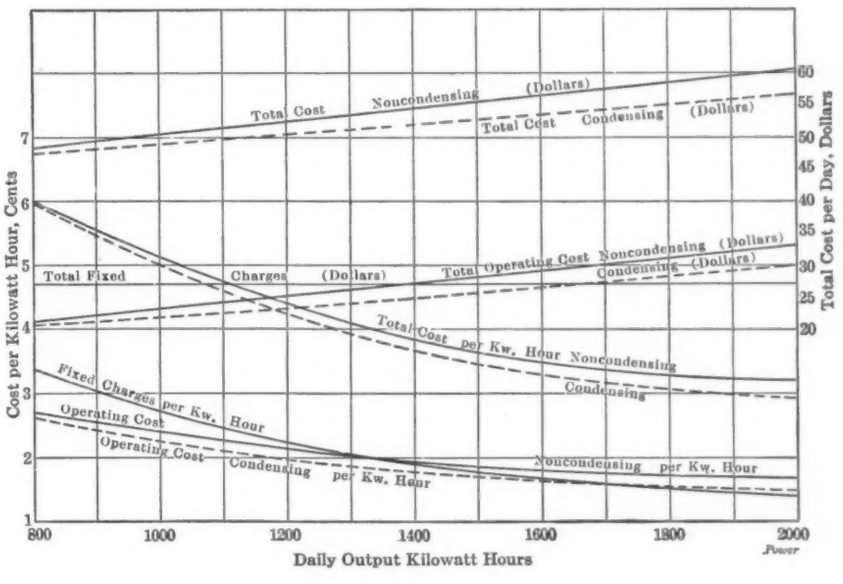
In the course of operation, where no superheaters are used, there is a distinct tendency for the turbine to be supplied with wet steam, the effect of which is very marked on the economy. Experiments that have been made show that the percentage increase in consumption is about twice that of the moisture in the steam. With 2 per cent. of moisture in the steam at the first row, the consumption is increased about 4 per cent.

Data on Central Station Operation

The recent report upon the operation of the new power plant at the coast artillery school, Fort Monroe, for the first three months of this year, contains some interesting figures on central-station operation.

This plant furnishes electrical energy for the interior and exterior lighting of the post (exclusive of fortifications), power for testing and shop purposes, live steam at 125 pounds for the engines in the laboratories, and either live or exhaust steam for heating the entire artillery school.

The daily output of the plant ranges from 800 to 2000 kilowatt-hours. The accompanying chart shows the total cost per kilowatt-hour based upon operating costs, fixed charges, interest and depreciation. The total cost of the installation is estimated at $42,209.55, the interest being placed at 3 per cent., and the depreciation at 7 per cent. The coal used was anthracite and cost $4.80 per ton of 2000 pounds.



COSTS FOR POWER AT VARIOUS OUTPUTS

Flue Gas Analysis and Calculations

By Julian C. Smallwood

The author briefly discusses the molecular theory, shows how to compute the amount of air required to burn a pound of carbon and presents calculations for determining the heat losses due to excess and insufficient air.

A few elementary conceptions are necessary to make calculations from a flue-gas analysis. One, that of the theory of the molecular structure of matter is commonly known, but it may be well to review it here. The smallest subdivision of any material which can exist by itself and yet retain all of the characteristics of the material is called a molecule. A molecule is composed of a number of so called atoms which are supposed to be the smallest subdivisions of matter. Any chemical compound is dependent for its identity upon the material of the atoms forming its molecules. Thus a molecule of CO_2 is composed of one atom of carbon and two of oxygen, while a molecule of CO has one atom of both carbon and oxygen. The molecule of the gas oxygen contains two atoms of oxygen. We may form a conception of these facts by imagining a pail of lead shot to be atoms of oxygen and one of iron shot to be carbon. If we stick a single lead shot to each iron one the result represents carbon monoxide. Similarly, oxygen gas would be represented by the lead shot stuck together in pairs; carbon by the iron shot in its single form, and carbon dioxide by one iron shot combined with two of lead.

The relative weights of atoms are definitely known. That of the gas hydrogen is the least; an atom of carbon is twelve times as heavy as one of hydrogen; one of oxygen sixteen times as heavy; and nitrogen, fourteen. We may, therefore, let the weight of an atom of hydrogen be a unit; a molecule of carbon then weighs 12 of these units; a molecule of oxygen weighs 32, since there are two atoms to the molecule; and the weight of a molecule of CO_2 is,

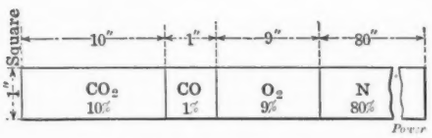


FIG. 1. PROPORTIONS OF THE GASES

$$12 + 16 + 16 = 44.$$

Tabulating the molecular weights of flue-gas constituents we have,

$CO_2 = 12 + 16 + 16 = 44$
$O_2 = 16 + 16 = 32$
$CO = 12 + 16 = 28$
$N = 14$

Each value means that a molecule of the gas referred to is equal in weight to that number of atoms of hydrogen. For convenience we may call the weight of the latter simply a "weight." Then CO_2 has 44 weights; O_2, 32, etc.

Now, since the gas analysis has furnished volumes and not weights, this would not do us much good if it were not for a very convenient physical law. This law states that in a given volume of any gas at a given pressure and temperature there is always the same number of molecules present.* We therefore know that in a vessel containing a mixture of gases there is the same number of molecules as though only one of those gases, or any gas, existed there alone, irrespective of the number of atoms in its molecules.

It follows that a volume of, say, two cubic inches contains twice the number of molecules that one cubic inch contains. Also, if the molecules of the larger volume are twice as heavy as those of the smaller, the weight of the larger volume is four times that of the smaller.

Fig. 1 represents a vessel, of one square inch cross-section and 100 inches long, containing flue gas. It is supposed that the constituents are separated in layers as indicated, the percentages by volume being CO_2, 10 per cent.; O_2, 9 per cent.; CO, 1 per cent.; and N, 80 per cent.

Let us suppose for the sake of argument that there is a single molecule of CO occupying the cubic inch shown. There will then be 10 molecules of CO_2, 9 of O_2, and 80 of N. The weight of the CO, as previously explained, is then 28 "weights"; that of the CO_2 is,

$$10 \times 44 = 440;$$

that of the O_2 is,

$$9 \times 32 = 288;$$

that of the N is,

$$80 \times 14 = 1120;$$

and the total weight is

$28 + 440 + 288 + 1120 = 1876$ *weights.*

The part by weight that the CO is of the whole is, therefore, $\frac{28}{1876}$; that of the CO_2 is $\frac{440}{1876}$, etc. It is thus clear that, knowing the parts of a flue-gas sample by volume, the parts by weight may be obtained simply by multiplying each of the former by the corresponding molecular weight and dividing by the sum of such products.

*Avogadro's law.

We have seen in the foregoing that the fractional part that any of the separate gases is of the entire weight may be found. Using the same method it may be determined what part any of the materials, such as oxygen or carbon, is of the whole or each other. Referring to Fig. 2, which is a rearrangement of Fig. 1, the nitrogen being omitted, the black circles represent atoms of carbon and the unshaded ones, atoms of oxygen. The figure represents a vessel each cubic inch of which contains one molecule of gas, the different gases being separated as shown. As before, the percentages by volume are 10 of CO_2, 9 of O_2 and 1 of CO. In each cubic inch of CO_2 there are two atoms of oxygen; in the cubic

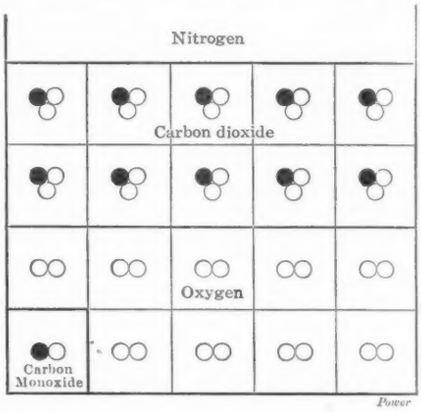


FIG. 2. DIAGRAM ILLUSTRATING COMBINATIONS OF ATOMS TO FORM MOLECULES

inch of CO there is one atom of oxygen; and in each cubic inch of O_2 there are two atoms of oxygen. Counting them, we have,

CO,	1 atom of oxygen.
CO_2, $2 \times 10 =$	20 atoms of oxygen.
O_2, $2 \times 9 =$	18 atoms of oxygen.
Total	39 atoms of oxygen.

Similarly, the number of atoms of carbon is,

CO	1 atom of carbon.
CO_2	10 atoms of carbon.
Total	11 atoms of carbon.

The total weight of oxygen is, therefore,

$$39 \times 16 = 624;$$

that of carbon is,

$$11 \times 12 = 132$$

weights. It thus appears that to obtain the weight of any of the materials it is only necessary to multiply the per cent. volume of each gas containing that material by the number of atoms of the material in one molecule of the gas; the sum of these gives the number of atoms of the material; multiplying this number by the atomic weight gives the result.

In the case cited the oxygen used to make the mixture is $\frac{624}{1876}$ of the whole.

And, since there are 132 weights of carbon and 624 of oxygen, there are $\frac{624}{132}$ or about 4¾ of O_2 to each one of C.

One of the important calculations based on flue-gas analysis is that for the amount of air furnished to the coal, expressed in pounds of air per pound of coal. This may be obtained by the use of the principles just given. The following explains the calculation:

All of the carbon in the coal, except that small part of it which escapes through the gate, is converted into gas and passes up the chimney. Also, all of the carbon in the flue gas comes from the coal, with the exception of a very small part of it which is introduced as CO_2 with the entering air. We may assume that the oxygen existing in the flue gas as free oxygen and that in combination with the oxygen contained in the CO_2 and CO, equals in amount the oxygen supplied to the furnace with the air. In the example given it was shown that there were about 4¾ weights of O_2 to each one of C actually existing in the chimney. According to our assumptions, then, there were 4¾ weights of O_2 actually furnished to the furnace for each weight of C burned. To produce this oxygen air must have been supplied equal in weight to,

$$4\tfrac{1}{3} \times 4\tfrac{3}{4} = 20.5,$$

since the weight of air is 4⅓ times the weight of the oxygen contained in it. The figure, 20.5, represents the weight of air furnished for each weight of carbon burned, and since the relation is between weights we may call them pounds. The result may therefore be expressed as 20.5 pounds of air per pound of carbon burned. Suppose that we had previously determined that the coal was composed of 90 per cent. carbon and 10 per cent. ash. We should require 10 per cent. less air to burn one pound of this coal than would be used to burn a pound of pure carbon. Hence,

$$20.5 \times 0.90 = 18.5$$

pounds of air required per pound of coal.

Now, this amount of air may be too much or too little to burn the coal properly. To determine the exact amount of air theoretically required for the complete combustion (that is, conversion to CO_2) of one pound of carbon, it is noted that one molecule of oxygen combines with one of carbon to make CO_2. Hence the weight of oxygen to each weight of carbon is $\frac{32}{12}$; and the number of pounds of air per pound of carbon is,

$$4\tfrac{1}{3} \times \tfrac{32}{12} = 11.5$$

It is found that unless more than the exact theoretical amount of air is supplied there will not be complete combustion; that is, part of the gas will be burned to CO instead of CO_2. It seems necessary, therefore, to furnish an excess of air and this excess may be fixed at 50 per cent. more than the theoretical amount. As before stated, the flue gases act as a vehicle for heat, and if there is more than the necessary excess of air, a greater loss of heat up the chimney results. Using the data of the example previously given, the weight of air used for each pound of carbon burned is 20.5. Assuming 50 per cent. excess of air to be the right amount, there should have been furnished

$$11\tfrac{1}{2} + (\tfrac{50}{100} \times 11\tfrac{1}{2}) = 17\tfrac{1}{4}$$

pounds. The difference between this and the air actually admitted is 3¼ pounds, and this is the unnecessary air admitted for the burning of each pound of carbon. The specific heat of air is 0.239, which means, as before explained, that if one pound of air is heated one degree of temperature, it has 0.239 B.t.u. added to it. Suppose that the excess air considered in the example is heated 500 degrees; that is, the temperature of the boiler room is, say, 70 degrees and that of the flue gas 570 degrees, the heat added to 3¼ pounds of air is then

$$3\tfrac{1}{4} \times 500 \times 0.239 = 388 \text{ B.t.u.}$$

Now, it has been found by experiment that a pound of carbon has a heat-value of 14,650 B.t.u. if completely burned to CO_2. The part of this heat which is carried up the stack by the 3¼ pounds of excess air is

$$\frac{388}{14{,}650} = 0.026, \text{ or } 2.6 \textit{ per cent.}$$

If it is desired to calculate the total heat lost up the stack (that is, the heat carried off not only by excess air but by *all* of the flue gases), an approximate value of the specific heat of these gases may be taken as 0.235. The weight of flue gas per pound of carbon must equal the sum of the weights of the air supplied and the one pound of carbon with which it combined or

$$20.5 + 1 = 21.5$$

pounds of flue gas per pound of carbon.

The heat added is therefore,

$$21.5 \times 500 \times 0.235 = 2500 \text{ B.t.u.}$$

The loss in per cent. is

$$\frac{2500}{14{,}650} \times 100 = 17 \textit{ per cent.}$$

It has been previously remarked that if CO is formed, what is called complete combustion does not take place, and not all of the heat possible is generated. If CO is the product of combustion, this product is capable of combining with more oxygen, which combination means further burning and which, since it is combustion, generates additional heat. When the carbon is changed entirely to CO_2, however, it is no longer capable of combining with oxygen and can give out no additional heat. As before stated, the heat value of a pound of pure carbon burned to CO_2 is 14,650 B.t.u. Similarly it has been determined experimentally that a pound of carbon burned to CO generates 4400 B.t.u. Clearly then, for each pound of carbon burned to CO instead of CO_2 the heat lost is

$$14{,}650 - 4400 = 10{,}250 \text{ B.t.u.}$$

Referring to the data of the example, the weight of carbon burned to CO is

$$1 \times 12 = 12$$

weights, since the volume of the CO is 1 per cent. There is, therefore, $\frac{12}{132}$ of a pound of carbon incompletely burned to each pound of carbon used. The heat lost through the incomplete combustion of this carbon is

$$\frac{12}{132} \times 10250 = 932 \textit{ B.t.u.}$$

the meaning of which is that for each pound of carbon burned there is a loss due to this cause of 932 B.t.u. Since it is possible to obtain 14,650 B.t.u. from one pound of carbon, the per cent. loss is

$$\frac{932}{14650} \times 100 = 6.4 \textit{ per cent.}$$

When making calculations as in the foregoing, it facilitates the work to first make a table as shown herewith. Columns 1 and 2 give the results of the flue-gas analysis. Considering the line in which CO_2 appears, for example, the figure 10 under column 3 is obtained by multiplying the per cent. volume by the number of atoms of carbon in one molecule of CO_2. In column 4 the number of atoms of oxygen is obtained in the same way. The molecular weight 44 has been

CONVENIENT FORM FOR FLUE-GAS CALCULATIONS.

1	2	3	4	5	6
	Per Cent., Volume.	In Each Flue Gas, the Total Number of Atoms of C.	of O.	Molecular Weight of Flue Gas.	Total Weight of Each Flue Gas.
CO_2	10	10	20	44	440
O_2	9	..	18	32	288
CO	1	1	1	28	28
N	80	..	..	14	1120
Totals	..	11	39	..	1876

Total weight of C = 11 × 12 = 132 weights.
Total weight of O_2 = 39 × 16 = 624 weights.
Total weight of C burned to CO = 1 × 12 = 12 weights.
Total weight of flue gases = 1876 weights.

calculated previously; multiplying it by the per cent. volume gives the weight of CO_2. It will not be difficult to understand these figures if it is remembered that it is assumed that 1 per cent. of flue gas by volume contains one molecule and that therefore the number of molecules in 2 per cent. is two, in 3 per cent. is three, and so forth. The assumption that 1 per cent. contains one molecule is permissible because "per cent." applies to *any* quantity; the proportions are the same whether 100 cubic feet of gas are considered or 100 cubic inches.

In presenting the calculations in the way in which they are here given, it is the writer's purpose to enable the operator to get results with the use of an apparatus for flue-gas analysis only. Such measurements as may be obtained by it are the only ones necessary to the foregoing calculations, with the exception of that for heat lost up the chimney. To determine this loss it is necessary to know the stack temperature, which may be found by the use of a special device called a pyrometer. A thermometer of the ordinary construction would be destroyed by the high temperatures. In consideration of the fact that a very considerable loss may result from having the stack temperatures too high, it is advisable to have a pyrometer on hand that this loss may be determined and kept within reasonable limits.

The heat losses calculated in this article have been compared with the heat value of a pound of carbon. It must be explained, however, that this is not usually done, the heat value of the coal being used instead. Since the furnace uses coal and not pure carbon, it is more reasonable to base results upon its heat value than that of carbon. But to obtain the former quantity, a special determination must be made; and to use it, the coal must be analyzed. To avoid this extra labor, the calculations may be made as explained and the results will not vary materially from those obtained by the more correct method of calculation.

If a coal analysis is made it furnishes the per cent. of carbon in the coal. This being known, all the heat losses may be found for one pound of coal instead of carbon, as was done in our calculation for the pounds of air per pound of coal. These losses may then be expressed in per cents. of the heat value of the coal instead of carbon.

It should be noted, too, that there are some nitrogen and hydrogen in the coal which appear in the flue gas along with the carbon and the constituents of the air. The hydrogen may combine with some of the entering oxygen and form water (water being a chemical combination of these materials). The flue-gas analysis as described, however, takes no account of water. The effect of the hydrogen in the coal, then, is to make our calculation for the pounds of air per pound of coal, a trifle less than the actual amount due to the oxygen turned into water.

Coal Handling, Wood Worsted Mills

At the time of our description of the power plant of the Wood Worsted Mills at Lawrence, Mass., some three years ago, the coal was conveyed from the storage alongside the boiler room to the firing line by means of tip carts drawn by horses. With the doubling up of the boiler plant then in use it appeared that mechanical conveyance would reduce the cost, and the system shown in the accompanying engravings has been installed.

The substitution of mechanical conveyance for tip carts drawn by horses to carry the coal from storage to the firing line resulted in a big reduction in the cost of handling. The conveying apparatus has a capacity of forty tons per hour.

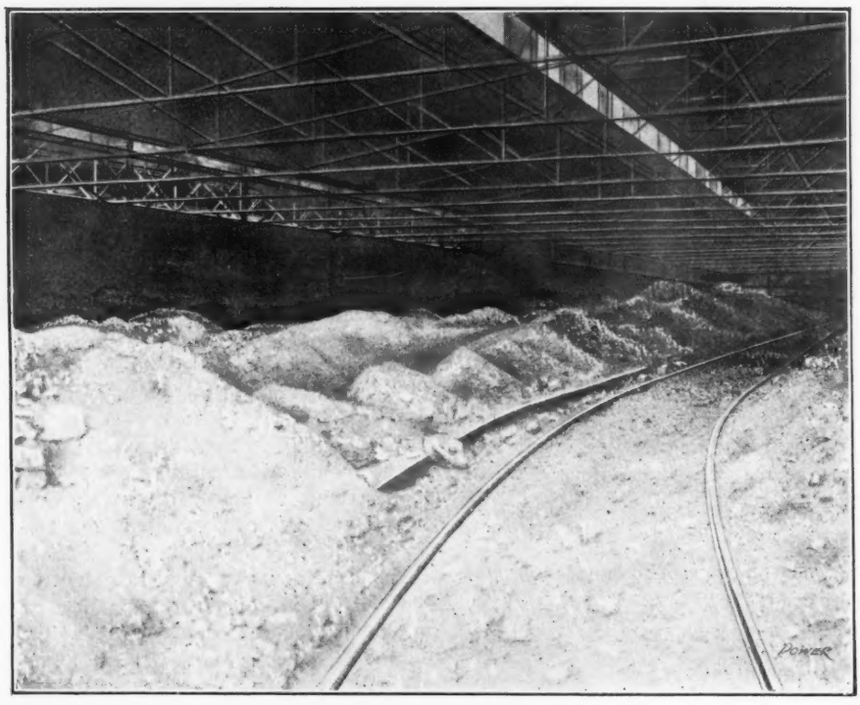


FIG. 1. COAL STORAGE SHED

Coal is brought into the storage shed, of which Fig. 1 is an inside view and Fig. 2 a plan and elevation, upon elevated spur tracks by the railroad. The trestles permit the use of side- or bottom-dumping cars, or cars which can be unloaded by the locomotive crane shown in the elevation of the storage shed in Fig. 2, and by a reproduced photograph in Fig. 5, by means of which the coal, however unloaded, may be trimmed and piled and worked over in any portion of the shed or yard.

Beneath three of the four tracks are hoppers, shown at *A A A*, in Fig. 2, and one in perspective in Fig. 3. When coal is wanted in the boiler room it is conveyed to one of these hoppers by the locomotive crane, the clam-shell bucket of which handles about a ton at a time and is discharged by the hopper upon a 48-inch apron conveyer, seen beneath the hopper discharge in Fig. 3 and indicated by *B* in Fig. 2, where it is shown extending under all three of the hoppers. This carries it to the 28x24-inch crusher, shown at *B* in the plan portion of Fig. 2, and better still in the elevation. A man watches the apron between the nearest hopper and the crusher and removes the coupling pins and other articles which frequently come along with the coal, and which the crusher might find it difficult to handle.

The crusher delivers the coal to a belt conveyer marked *D* in Fig. 2 made of five-ply rubber belt 20 inches in width, running at 210 feet per minute. This passes beneath the flag pavement of the alley separating the storage shed from the boiler house, and enters the latter

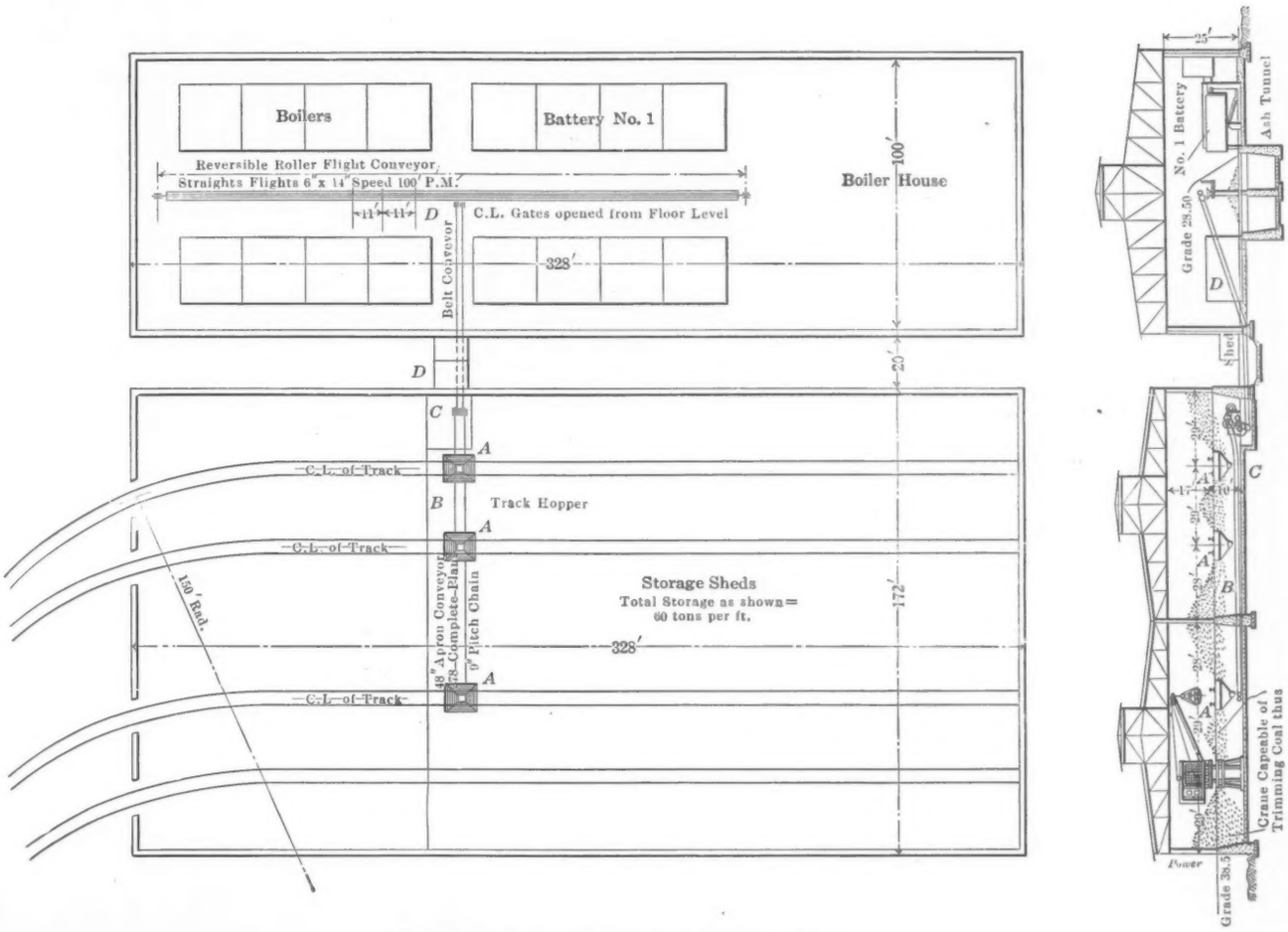


FIG. 2. PLAN AND ELEVATION OF STORAGE SHEDS

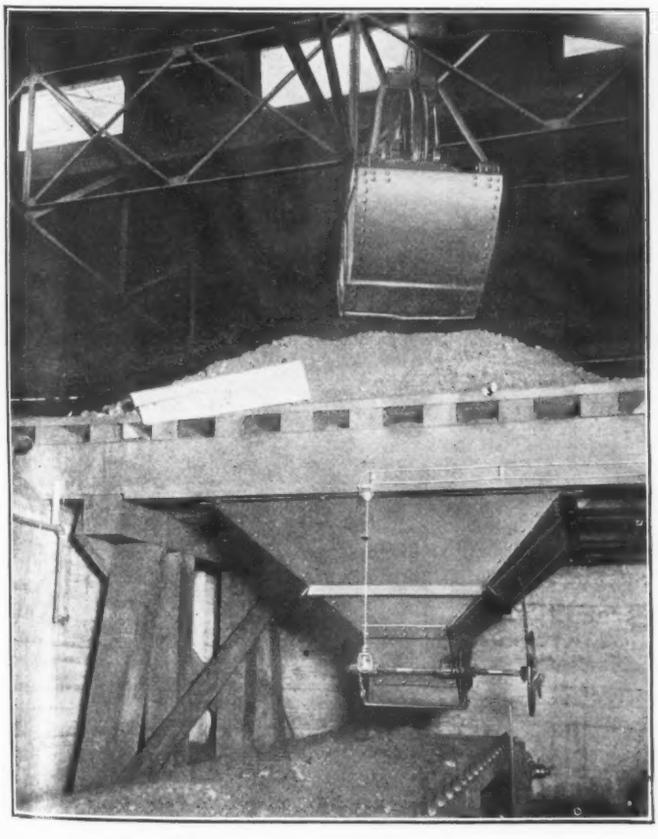


FIG. 3. COAL HOPPER BENEATH TRACK

FIG. 4. BELT CONVEYER ENTERING BOILER HOUSE

FIG. 5. LOCOMOTIVE CRANE

upon an incline, as shown in the elevation in Fig. 2 and in Fig. 4, delivering to the reversible roller flight conveyer extending through the center of the firing room, as shown upon the plan and in Fig. 6. This conveyer can be run to

FIG. 6. REVERSIBLE ROLLER FLIGHT CONVEYER IN BOILER ROOM

carry the coal in either direction and through gates can be set to discharge it at any point, forming a continuous bank within easy reach of the firemen of the boilers upon both sides.

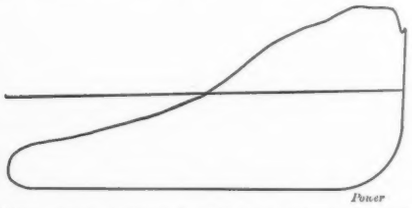
The requirements of the plant, if all of the boilers were in use at their maximum capacity, would be some 20 tons per hour. The conveying apparatus can easily handle 40. For its operation there are required three men, one on the locomotive crane, one at the apron and one on the distributing gallery in the fire room. The handling by the cart method required nine men and three carts and horses. The crane would be almost essential even if the conveyance by carts were continued for bringing in coal from the yard storage and for trimming and piling above the level at which the cars are dumped. The crane was designed and built by the J. M. Dodge Company, and the conveying machinery by the Link-Belt Company.

[Note: The credit of installing the coal-conveying system at the Wood Worsted Mills belongs to Charles A. Hardy, assistant treasurer of the mills. When I designed this plant first, having twenty boilers running, I thought horses and carts would be the cheapest thing, but after the whole plant was running I found that I was mistaken. The coal conveyer has proved a big saving to us.

GEORGE H. DIMAN,
Consulting Engineer.]

Faulty Cylinder Construction

The accompanying diagram shows a condition that ordinarily would cause an engineer to think overtime in an endeavor to locate the trouble. In this instance, the drop in the admission and steam line occurs on the head end of the low-pressure cylinder and on the crank end of the high-pressure cylinder of a cross-compound Corliss engine. It kept the engineer busy for a time finding out what caused the defect in the diagram, and changes in the eccentric both back and forward made practically no difference in the formation of the drop.



NOT THE RESULT OF A LEAKY VALVE

At last the indicator cock on the head end of the low-pressure cylinder was removed while the writer happened to be present and a ½-inch rod, the same size as the hole in the cylinder, was inserted with the piston on the head-end dead center. An obstruction was found, which proved to be the piston of the engine. This solved the question in all probability, as it will doubtless be found that there is no channel cut in the head so that the indicator cock on that end of the cylinder can get full steam pressure at the beginning of the stroke. The engine is built by a well known manufacturer, and as the same defect occurs on one end of both cylinders, it does not speak well for carefulness in the little details of construction.

Many men working in an engine room class themselves as engineers, and their work as engineering. Wrong! Starting and stopping an engine does not make an enginer; neither is such work of a professional order. Guess again.

Centrifugal Pump Characteristics

A set of test figures, usually represented by a group of curves known as characteristics, shows what may be expected of a certain pump under various conditions of head and output. Characteristics are useful in selecting a pump for a given class of work.

The performance of a centrifugal pump is completely known when simultaneous values have been obtained for the following quantities: speed, usually in revolutions per minute; head, usually in feet of water or pounds per square inch; delivery, usually in gallons per minute or cubic feet per minute; power consumption, usually in horsepower.

Since centrifugal pumps are ordinarily designed to operate at a fixed speed, the inter-relations of the other quantities involved under conditions of constant speed only will be discussed. These relations are most conveniently shown by a chart, as in Fig. 1. The values used in preparing this chart are obtained as follows:

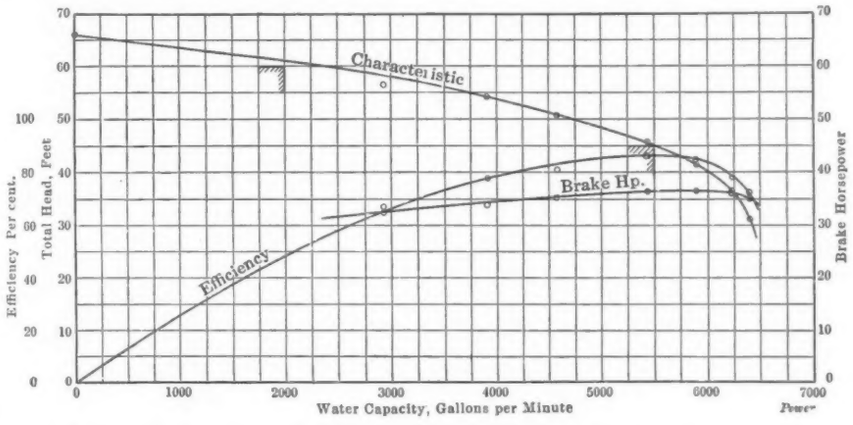


FIG. 1. CHARACTERISTIC OF PUMP SUITABLE FOR BAROMETRIC CONDENSER

The pump is first connected up as shown in the diagram in Fig. 2. The total suction head, including both the vertical lift and the friction of the piping, is measured by a suction gage connected to the suction pipe as nearly level as possible with the middle of the suction opening on the pump, while a pressure gage is likewise connected to the discharge pipe. The latter gage will indicate the total discharge pressure pumped against, including friction head as well as vertical lift.

The discharge of the pump may be measured in several ways. The standard calibrating method that has been found both most convenient and most accurate by the De Laval Steam Turbine Company, to whom we are indebted for the accompanying sketch and drawing relating to De Laval pumps, involves the use of standardized nozzles. These nozzles are made of a peculiar shape to secure the highest possible coefficient of discharge. By taking the velocity of the discharge with a Pitot tube, as shown in the diagram, the volume of the discharge may be calculated with great exactness. The vertical column connected to the Pitot tube may contain either water or mercury, according to the head to be measured.

Inasmuch as mistakes are frequently made in calculating centrifugal-pump efficiencies, it may be well to state that the total head generated consists of the suction head measured at the entrance of the pump, that is, including the friction as well as the vertical lift, plus the pressure head measured at the discharge, plus the difference in level, if any, measured between the two gages, plus the gain in velocity head between the two points where the gages are connected, if the suction and discharge pipes do not happen to be of the same size.

The speed being kept constant throughout the test, the delivery is controlled by means of a throttle valve in the discharge pipe. When the pump is discharging water at a certain constant rate, the corresponding total head generated is read from the gages. From voltmeter and ammeter readings, taken simultaneously, and from the known efficiency of the driving motor, the horsepower consumed at the same instant in driving the pump is calculated. The rate at which mechanical work is done on the water is derived by multiplying the head generated by the rate of delivery. Dividing this product, as expressed in appropriate units, by the power delivered to the pump shaft, the mechanical efficiency is obtained.

Having these values for head, delivery, power and efficiency, a distance corresponding to the rate of delivery is measured horizontally on the scale at the bottom of the chart. Vertically above this, and according to the scale or scales at the left of the chart, points are located for the head, power and efficiency values obtained for the same instant. The opening of the valve in the discharge is then changed, changing the flow, whereupon readings are again made of all quantities as before, and the corresponding points marked on the chart. Repeating this operation a sufficient number of times, a series of points will be obtained for head, power and efficiency, from no delivery to full delivery. A smooth line drawn through the points for head is called the head-capacity curve or "the characteristic" of the pump at the given speed. A similar line drawn through the points for efficiency is known as the efficiency characteristic, while a third line drawn through the points for horsepower is called the horsepower characteristic. All three curves, taken together, are

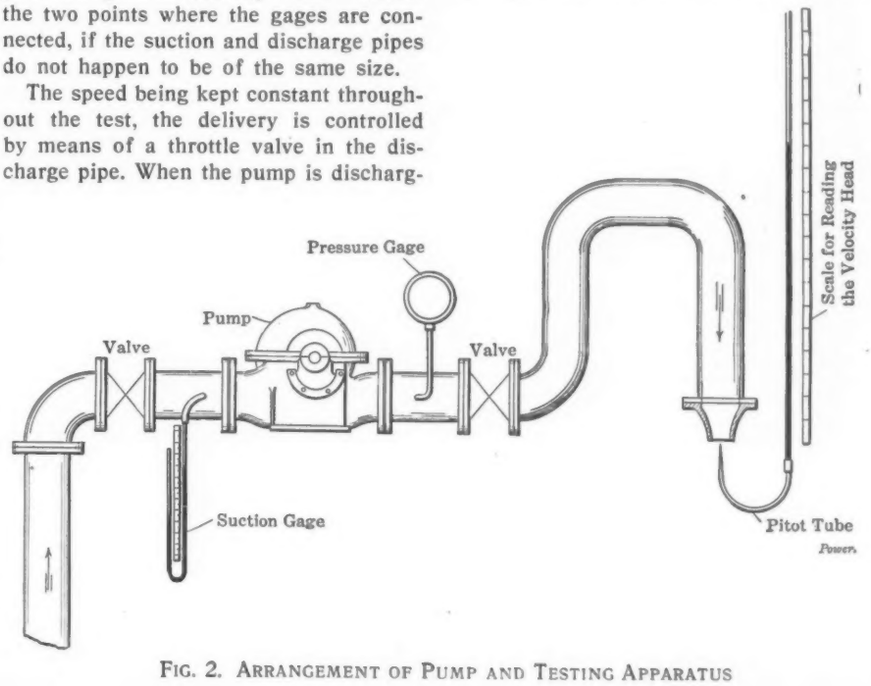


FIG. 2. ARRANGEMENT OF PUMP AND TESTING APPARATUS

known as the "test characteristics" or performance curves of a particular pump at a given speed.

From an inspection of the characteristics of a given pump, its suitability for any particular service may be determined. Suppose that we are selecting a pump to supply water from a lower level to a barometric condenser. The pump should preferably be able to start the flow of water when there is no vacuum on the condenser and will therefore be required to generate a head equivalent to the full difference in the level between the suction sump and the top of the condenser. On the other hand, when the vacuum has been established the head to be generated will be diminished by the amount of the vacuum. That is, of a total difference in level of 60 feet, the pump will need to contribute only about 35 feet of the total head when the vacuum is on and the pump should be able to handle water under both conditions with good efficiency when running at a constant speed. The characteristics of a pump especially designed for this kind of service are shown in Fig. 1.

As will be observed, the characteristic, that is, the curve showing the relation between the total head developed and the delivery in gallons per minute, has a considerable slope, starting in with about 66 feet at normal delivery and falling to about 42 feet at a delivery of 5850 gallons per minute. The design of the pump is such that the highest efficiency, namely, 83 per cent., is obtained under the normal conditions; that is, when the pump is delivering the larger quantity of water against the lower head, although the efficiency under starting conditions, when the pump must generate a 60-foot head to lift the water to the condenser without the help of the vacuum, is very fair, being about 50 per cent.

The characteristics of a pump having a still steeper head-delivery curve are shown in Fig. 3. As will be noted the head falls from about 64½ feet at no delivery to about 27 feet at a delivery of 12,000 gallons per minute, which is the rate of delivery for which the pump was designed and at which point its efficiency is 76 per cent. It will be noticed that the efficiency of this pump is remarkably uniform, being practically 70 per cent. all the way from a delivery of 7200 gallons per minute up to 13,200 gallons per minute.

Inasmuch as the efficiency is very nearly constant with increased delivery and a rapidly falling head, it will be of interest to note what is happening to the motor simultaneously. The brake horsepower consumed by some pumps increases rapidly with increased delivery; in fact, a pump may cause the motor to be burned out if pressure be removed from the discharge. In the case of this pump, however, it will be noted that the brake horsepower reaches a maximum of about 130 at a delivery of 8400 gallons per minute and thereafter decreases, falling to about 114 horsepower at a delivery corresponding to nominal rating, namely, 12,000 gallons per minute. A pump of the type just discussed would be ideal for such service as pumping out drydocks. At the start, when there would be practically no head to overcome, it would handle enormous volumes of water at high efficiency and it would continue pumping with good efficiency against a steadily increasing head until the dock were entirely emptied.

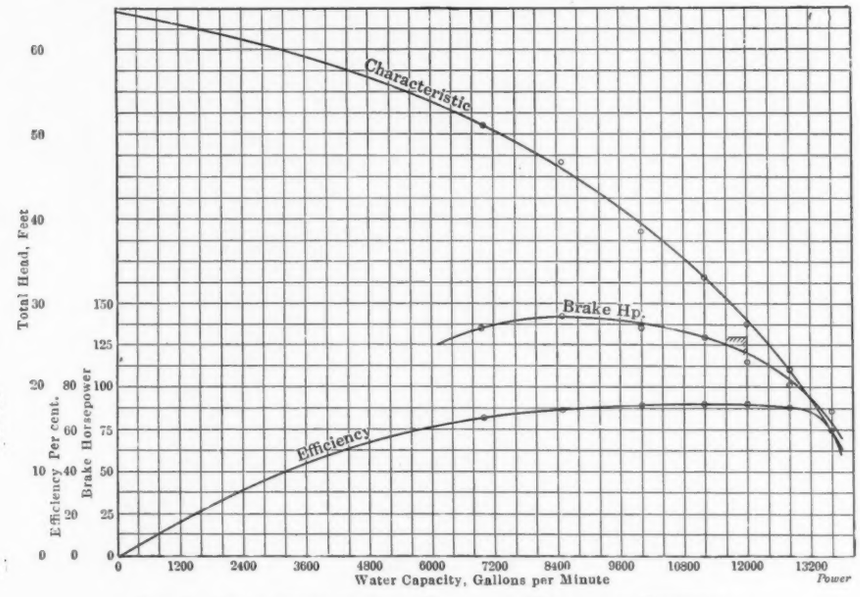


FIG. 3. CHARACTERISTICS OF PUMP FOR EMPTYING DRYDOCK

At no point would there be any danger of overloading the motor, since the horsepower consumed reaches a maximum at a delivery of about 8500 gallons per minute. After this the power taken by the pump diminishes, as above pointed out. This automatic protection to the motor is secured, not by the addition of governing apparatus or other contrivances to modify the speed or to change the form of the pump passages, but by the permanent shape of the impeller and other parts of the pump, and a pump having these qualities will, therefore, retain them under all conditions and at all times. This property of the pump makes it possible to use a smaller and less expensive motor and, further, it permits the selection of a motor having the maximum efficiency at the output coinciding with the demands of the pump under normal operating conditions. Electric motors, as now built, have only a limited overload capacity, and although it might be possible to equip a pump with a motor of sufficient size to provide for any overload, such practice is not at all economical.

In considering the efficiency of a centrifugal pump, the shape of the efficiency curve should be taken into account, as well as its maximum efficiency; that is, it hardly ever happens that a pump is at all times operated at the delivery for which it was designed or at the delivery corresponding to the maximum efficiency, and the average efficiency at the different deliveries which the pump will be called upon to meet in actual service is more important. If the efficiency curve is steep, the efficiency will fall off greatly as delivery is reduced, while, on the other hand, if the efficiency curve is flat, the efficiency will be fairly high through a wide range of load. It sometimes happens that a large pump is bought with a view to a possible increase later on in the amount of water required. This, however, will result in operation at low efficiency at the beginning and in most cases it will probably be advisable to buy a smaller pump to begin with and add another pump or replace with a larger pump when necessary.

The small shaded corners under the head-delivery curves indicate the conditions specified by the purchaser before the pump was built and the proximity of this point to the curve shows how closely the desired results were achieved by the designer. In other words, when the pump was purchased, a certain speed, head and delivery were specified and it became the designer's task to obtain the required head and delivery at the specified speed and at the same time to so design the pump that it would give the highest efficiency at this point. Accuracy in predetermining the characteristics of a pump is important from the point of view of the motor, since if the pump is to be driven by an alternating-current motor, it may prove very difficult to modify the speed after installation or at least such modification will involve diminished efficiency. On the other hand, it is poor practice to purchase a pump which gives too high head and to reduce the head by throttling, since this involves a direct loss of energy.

Application of Thermal Storage

During the past few years the employment of thermal storage in connection with a number of large boiler plants in England has resulted so successfully as to insure its permanent and extended use. The following from *The Engineer* refers briefly to the general principles of thermal storage and some of the theories advanced to account for its results.

By means of a tank located just above the boiler and connected by pipes to both the steam and water spaces of the latter, feed water is heated to the steam temperature during periods of light load, to be available during periods of peak load. The scheme is analogous to that of a flywheel on an engine or to a storage battery in connection with a dynamo.

A spherical-ended cylinder is erected above the boiler in any convenient position, and is connected to it by means of a steam pipe leading from the steam space of the boiler through the lower surface of the storage cylinder, and extending into the interior of the latter to within a few inches of the inner and upper surface. The generation of steam within the boiler thus fills the storage cylinder with steam at boiler pressure. From the lower part of the storage drum a second pipe, provided with a valve, leads into the boiler and terminates below the water level. In this way, feed water introduced into the storage drum is heated by coming in contact with the live steam to the temperature corresponding to the boiler pressure, and passing through the valve on the second pipe it descends by gravity into the boiler, there mixing with the water already present. The valve on the second pipe is employed to regulate the amount of water fed to the boiler, and by operating this suitably it can be arranged so that during periods of light load the flow of water into the storage cylinder is greater than that taken from it. In this way, during such periods, a supply of hot water is gradually accumulated until the vessel is nearly full. With the arrival of the peak load, when under ordinary circumstances the boiler would have to be forced to meet the demand, the hot water already in the vessel is drawn upon for the purpose.

Thermal storage does for the boiler what a flywheel accomplishes for the engine, or storage batteries do for the dynamo. But in the mere provision of a flywheel there is nothing to cause an increase in the aggregate output of the engine. Such, however, is the case with the thermal-storage plant, for it is found that at all times, whether the boiler is fed exclusively from the storage drum, as during the time of peak loads, or under ordinary circumstances, when the water first passes through the drum on its way to the boiler, the evaporation is increased by anything from 50 to 150 per cent., as compared with what is obtained even with economizers in use.

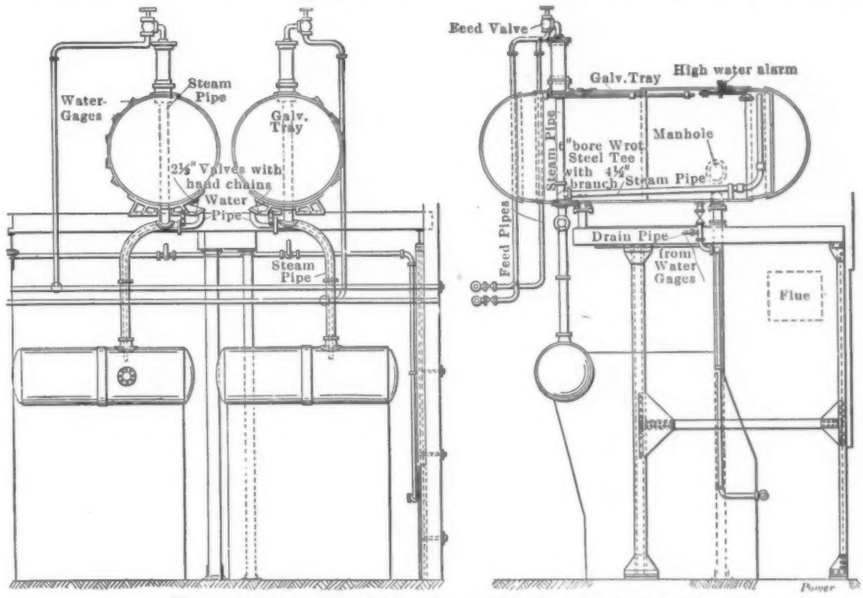
It has been suggested that these feed reservoirs permit the boiler to be forced with satisfactory results to an extent which under ordinary circumstances would inevitably entail a prohibitive amount of priming. Again, the introduction of the feed water at the same temperature as the steam in the boiler is known to produce smoother working, and in the absence of the irregular generation of steam may be found the principal factor in the causes leading to the enhanced output.

A test recently conducted by Prof. J. D. Cormack on the maximum output from a water-tube boiler fitted with and without the storage system gave the following results:

	Without Thermal Storage.	With Thermal Storage.
Duration of test, minutes	100	65
Draft in inches of water at chimney base	1.04	1.08
Gage pressure, pounds per square inch	197	201
Evaporation per hour, pounds of steam	14,830	26,080
	Per Cent.	Per Cent.
Output in terms of the rated capacity of the boiler (12,000 pounds steam per hour)	123.6	217.3

The accompanying sketch shows thermal-storage tanks applied to water-tube boilers at the plant of the St. Pancras Borough Council. It will be seen that the drums are erected on a steel gantry above the boilers, each drum being directly over the boiler which it is intended to serve. From the front steam drum of each boiler a pipe leads upward to the underside of the storage vessel, inside of which it branches into two parts, one limb rising straight upward and one passing at a slight inclination to the back of the vessel's interior and then upward. Directly above the first of these branches is placed a tower and to this point the feed water is led. Passing through a stop valve, the water descends through a spraying nozzle, and becomes mixed with the steam. The pipe leading from the water space of the storage vessel to the water space of the boiler drum is led off from the under surface of the former, and in order to avoid making an additional joint on the boiler, this pipe is made to pass within the uprising steam pipe. The storage vessels are also provided with a blowoff pipe, water gages and a high-water alarm.

An important feature of these storage vessels is that where the feed water is of a hard or impure character, the lime and other impurities are found to deposit themselves within the storage vessel rather than in the boiler proper. This being so, the accumulated deposit is readily removed by blowing off, as the absence of any direct contact between the storage vessel and the heat of the furnace prevents this deposit from being baked to a hard scale. In fact, the lime, etc., contained in the feed water passes through the blowoff valve of the storage vessel in a soft, powdery state.



THERMAL STORAGE APPLIED TO WATER-TUBE BOILERS

Mechanical Refrigeration

By F. E. Matthews

A short review of the history of the development of the art from the time of primitive man up to present day practice.

It has already been stated that in the study of mechanical refrigeration the real entity to which we must direct our attention is heat. The two principal sources of heat are chemical reaction and solar radiation. The most important of all chemical reactions to the engineer, and in fact, to the world in general, is that of combustion; but even this source of heat has its origin in solar radiation.

Primitive man was forced to depend for his comfort on solar heat irregularly dispensed, supplemented by the combustion of the most easily available fuels. If he chanced to be fortunate in hunting he feasted; if not he fasted perforce. When the sun favored him with sufficient heat to keep him warm, his fresh meat quickly became unfit for use, for he knew not the luxury of modern cold-storage facilities. When the sun's heat became less, so that he could keep his provisions untainted, he was kept busy gathering kindling wood.

Long before the appearance of man, however, provision had been made by nature to alleviate the discomfort brought about by the irregularity of solar heat. At an early period it seems that the earth's atmosphere was very rich in carbon-dioxide, and contained much moisture; a condition favorable to a rank growth of plant life. The carbon-dioxide which is absorbed by the vegetation, is broken up and the carbon becomes a fixed part of the plant structure while the greater part of the oxygen returns to the air. The energy necessary for this chemical process is derived directly from the sun. During this period of enormous growth, vast quantities of vegetation, becoming buried beneath the surface, fell into partial decay, and finally became coal. Thus it was that there was stored up beneath the surface of the earth in these great carbon deposits, an enormous amount of latent solar energy. There it remained until man's ingenuity and industry, prompted by ever-increasing necessity, set him to burrowing in the ground to bring up the blackened remains of primeval forests, and so making the latent heat pay the price of liberty by carrying his burdens and turning the wheels of his factories.

While this source of heat was found accessible to meet the demands of variable weather, it still remained for man's ingenuity to devise some method of doing away with the alternate feasting and fasting made necessary by the heat and the exigencies of the hunt. In this he had the advantage of nature's most practical object lessons.

At first he did not stop to consider that in the freezing of natural bodies of water, large quantities of heat must pass to the air and surrounding objects, thereby virtually heating them, or that in order for the ice to melt similar quantities of heat must return to the water from the air and surrounding objects, thereby refrigerating them. He simply thought he observed that frozen water, produced by some mysterious power that the cold north wind brought from the realm of ice and snow, was nature's favorite cooling material, and as his needs for cooling effects developed, his first thought was to store away a quantity of this product each winter in the caves which nature likewise thoughtfully provided.

With certain slight refinements in the operation, this same crude method employed by our primeval ancestors is still being used to no unconsiderable extent. The fact, however, that summer requirements must be anticipated at least one season by both nature and man, has combined with a score of other elements to force the introduction of more scientific methods.

Laboratory methods of producing low temperature by means of so called "frigorific mixtures," by which a perceptible drop in temperature is produced by certain endothemic chemical reactions and solutions have been known for at least three centuries.

Probably the most common example known of a frigorific mixture is that of ice or snow and salt. As has already been stated, the addition of a foreign substance to a liquid lowers its freezing point. The effect of the addition of different amounts of common salt (Na Cl) and that of calcium chloride (CaCl) is clearly set forth in the accompanying table. Since the addition of 10 per cent. of salt, by weight, to water lowers its freezing point to 18.7 degrees Fahrenheit and prevents its changing to the solid state till that temperature is reached, it would follow that the addition of the same percentage of salt to snow or finely divided ice would cause it to return to the liquid state at all temperatures above 18.7 degrees Fahrenheit. The result is that the ice at once begins to melt, but to do so it must absorb 144 B.t.u. of heat per pound, and in the event that this heat is not forthcoming, the temperature of the mixture will continue to fall until the freezing point corresponding to the per cent. solution is reached. At this point it will continue to exist in the solid state, and aside from the lesser intimacy of the mixture of the two constituents, ice and salt, will be the same substance as frozen brine of the same per cent. composition, and will exist under the same conditions of temperature.

EFFECT OF DIFFERENT AMOUNTS OF SALT ON FREEZING POINT OF LIQUID.

Calcium Chloride (CaCl) Brine.				Sodium Chloride (NaCl) Brine.			
Degrees Salinometer at 60° Fahr.	Specific Gravity at 60° Fahr.	Specific Heat.	Weight Pounds Per Cubic Foot.	Degrees Salinometer at 60° Fahr.	Specific Gravity at 60° Fahr.	Specific Heat.	Weight Pounds per Cubic Foot.
12	1.024	0.980	63.923	4	1.007	0.992	62.862
27	1.041	0.904	65.082	8	1.015	0.984	63.361
36	1.058	0.936	66.066	10	1.019	0.980	63.611
40	1.076	0.911	67.169	12	1.023	0.976	63.860
44	1.085	0.896	67.931	14	1.026	0.972	64.048
52	1.103	0.884	68.755	16	1.030	0.968	64.297
62	1.121	0.868	69.979	20	1.037	0.960	64.734
80	1.159	0.844	72.456	24	1.045	0.946	65.234
88	1.179	0.834	73.599	28	1.053	0.932	65.733
95	1.199	0.817	74.847	32	1.061	0.919	66.173
104	1.219	0.799	76.096	36	1.068	0.905	66.669
112	1.240	0.778	77.407	40	1.076	0.892	67.159
120	1.305	0.767	81.464	48	1.091	0.874	68.105
				60	1.115	0.855	69.603
				80	1.155	0.829	72.101
				100	1.196	0.783	74.660

The specific gravity of a substance is the raito of the weight of that substance to the weight of the same volume of pure water at its temperature of maximum density at 39 degrees Fahrenheit, at which temperature it weighs 62.425 pounds per cubic foot. The weight per cubic foot of brine given in the table is determined by multiplying 62.425 by the specific gravity as determined by a salinometer or other similar hydrometric instrument.

The greatest of all heat-absorbing changes in state of matter is that of vaporization. Since increase in pressure has the effect of raising the boiling point, or the temperature at which the liquid vaporizes, and decreasing the pressure has the effect of lowering it, it is only natural that reduction in pressure below that of the atmosphere or vacuum was first employed in attempts to cause some of the better known liquids to boil at sufficiently low temperatures to produce artificial "cold."

While there is evidence that some little experimenting was done with liquids under vacuum as early as 1755 there is no authentic information that anything of real importance was accomplished until the early part of the last century, when several independent inventors built experimental machines, none of which, however, seem to have produced any very encouraging results until Jacob Perkins, an Englishman, developed an ether-compression machine which he patented in 1834.

Perkins operated his ether-compression machine under vacuum, much as our present day ammonia-compression machines are operated when low temperatures are required. His patent of August, 1834, described his machine as being composed of the four principal parts which constitute our present machines, viz., a containing chamber or evaporator in which the refrigerating medium evaporates and through the walls of which it passes heat from the substance it is desired to refrigerate; a pump or compressor for drawing the evaporated refrigerant from its containing chamber and exerting upon it sufficient pressure to cause it to liquify when cooled; the cooler or condenser consisting of a coil of pipes submerged in water, and in which the refrigerant is cooled and liquified after compression; and a regulating or expansion valve for controlling the flow of the refrigerant liquified in the condenser as it passes under the higher condensing pressure to the evaporator maintained under a lower pressure due to the action of the compressor.

The evaporator shown in the Perkins patent consists of a circular tank made of two dished metallic disks, which receptacle was submerged in the fluid to be refrigerated. The compressor was designed to be operated by hand but otherwise the general arrangement of its working parts, except for the fact that the cylinder was invented, was very much the same as that of our present small single-acting ammonia compressors with both suction and discharge valves in the head. A simple submerged condenser, consisting of a single zigzag coil, and a hand-operated expansion valve were employed.

Both the compression and the absorption machines find their origin in the demonstrated possibility of liquifying so called gases. In 1823 Faraday announced to the world that he had succeeded in liquifying chlorine, ammonia and carbon-dioxide, as well as several other gases of less importance to the refrigerating industry.

By the same method by which Faraday first accidentally liquified chlorine, carbon-dioxide, ammonia, sulphur-dioxide, methyl-ether, Pictet fluid, sulphuric ether, ethel chloride, water, and other substances may be liquified experimentally under the proper conditions of temperature and pressure.

The first ammonia-absorption machine recognized as such, was invented by Carré about the year 1855, in which same year Harrison, an Australian, and Professor Twining, an American, are said to have independently perfected the Perkins ether machine, the latter inventor having performed the then marvelous feat of artificially freezing blocks of ice with fish inside.

Not the least among the influences that have combined to forward the development of mechanical refrigeration has been the pollution by sewage of the water from which the national ice crops are harvested. This has been especially true since it has been demonstrated that negative bacteriological tests, no matter how carefully conducted, are not insurance against typhoid, and there is accordingly well founded and rapidly growing prejudice against all ice known to be cut from sewage-bearing streams and lakes.

The breweries were among the first to adopt improved methods of cooling largely because of contamination of products through the unsanitary conditions inevitably resulting from the use of ice. This, together with the heavy labor charge which it entails, forced the development of a system of mechanical refrigeration. While the item of contamination was somewhat less important in the abattoirs than in the breweries, the enormous amounts of ice consumed and the uncertainty of the natural crop, made the adoption of mechanical refrigeration in this industry imperative from an economic standpoint.

In cold-storage work the inability of ice, without the addition of salt, to produce sufficiently low temperatures to satisfactorily preserve many perishable products, has of late years, at least, probably been the most patent factor in the combination to force the substitution of mechanical systems for ice in the cold-storage industry.

The demand for artificial means for producing refrigeration having first appeared among the larger industries above cited, the builders of refrigerating machines first set about to supply systems best adapted to their peculiar requirements. Later as the requirements of the larger consumers of cold began to show signs of having limitations, the builders began to look for other fields and quite naturally began to develop systems better adapted to the requirements of smaller consumers of ice. While the idea is still current with a certain class of consumers that food products kept in mechanically cooled compartments suffer thereby, the intelligent merchant is willing to acknowledge the superiority of mechanical cooling means in almost every case.

The chief factor which fixes the capacity limit under which it becomes commercially impracticable to install small mechanical refrigerating plants has been the cost of attendance which is practically as great for all smaller sizes as for those of from five to ten tons capacity, and this, in the general case in which steam power is employed 24 hours per day, solely for the operation of the refrigeration plant, becomes practically prohibitive. The first step toward surmounting this obstacle was to operate the plant in the daytime only in order to eliminate the expense of night attendance. In order to do this the brine-circulating system commonly called the "brine system," which will be described in detail later, was introduced. The brine system, however, usually consumes power 24 hours per day, and in order to reduce this expense the "congealing-tank" system, which will also be described in detail in a succeeding issue, was employed to some considerable extent.

Where steam is not required for other purposes and the amount of power necessary for the refrigerating plant is small, the substitution of combustion-engine power is often capable of reducing the cost of fuel as well as that of attendance; the former where cheap kerosene, crude or fuel oils of light density can be procured, and the latter where licensed attendants, insurance, and other factors work disadvantageously for the small steam plant.

The comparatively low first cost, as well as that of combustion-engine power, coupled with the slight expense for attendance now made possible by the application of certain automatic regulating and safety devices, makes this type of plant when properly installed either with or without "congealing tanks" as the case may require a most practical and satisfactory plant for the small consumers of ice. To the end of producing a small mechanical refrigerating plant capable of operating with still less attendance, so called completely automatic systems which will also be described in detail, have been developed. While it is a fallacy to suppose that these machines will operate without some attendance, they are often capable of operation with far less attendance than any other type, and were it not for the usually comparatively high cost of electric power necessary for the operation of a completely automatic plant, the advantages gained would undoubtedly more than compensate for the high first cost of such plants.

No one type of plant can be expected to be the most advantageous under all requirements, and the relative advantages and disadvantages of one over the other in first cost, operating cost, superiority of design, and safety should be carefully considered and balanced up before a decision is made.

Electrical Department

Storage Batteries in Isolated Plants

By Norman G. Meade

Especially conducted to be of interest and service to the men in charge of the electrical equipment.

It is generally recognized now that where uninterrupted 24-hour service from an isolated plant of moderate size is desired, a storage battery is practically a necessity. Usually, the engine and generator capacity in an isolated plant is sufficient for the total number of lamps connected, although they are seldom all in use at one time; consequently, the plant operates at but partial load during the total lighting hours. This means low efficiency, poor regulation and high fuel costs. The installation of a storage battery corrects this weakness by permitting the operation of the generator at the full or the most economical load for a few hours and then shutting it down entirely, the battery providing the current for the balance of the time. In many cases it can be so arranged that the generator need be operated only every second or third day, and then during the most convenient part of the day.

When on special occasions extra lighting is required, the battery may be discharged in parallel with the generator, and current equal to their combined capacity may be supplied.

The principal function of a storage battery in small plants being the furnishing of current for a considerable period of time, the operation of the battery consists of cycles of charging and discharging covering practically the capacity of the battery.

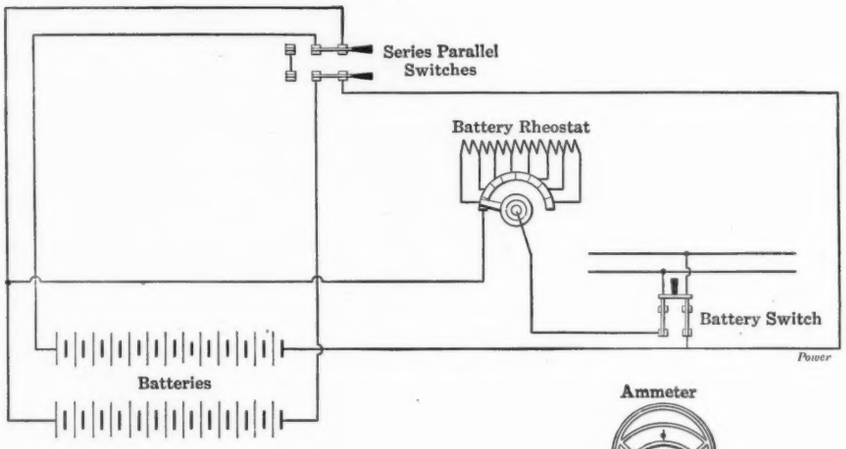


Fig. 1. Elementary Connections for Charging in Parallel and Discharging in Series through a Rheostat

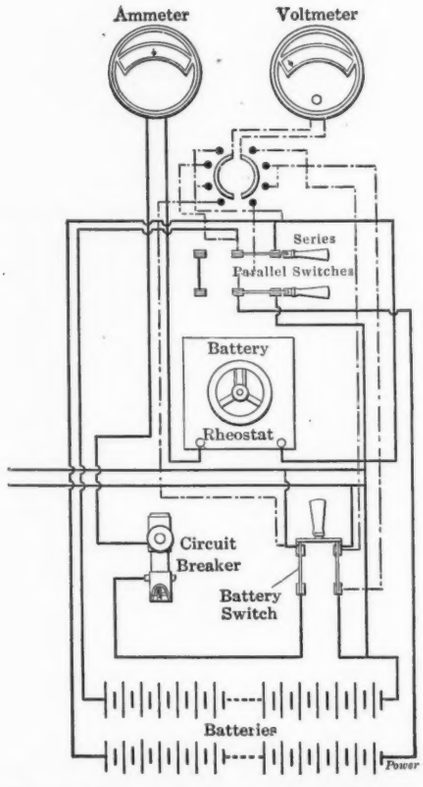


Fig. 2. Complete Switchboard Corresponding to Fig. 1

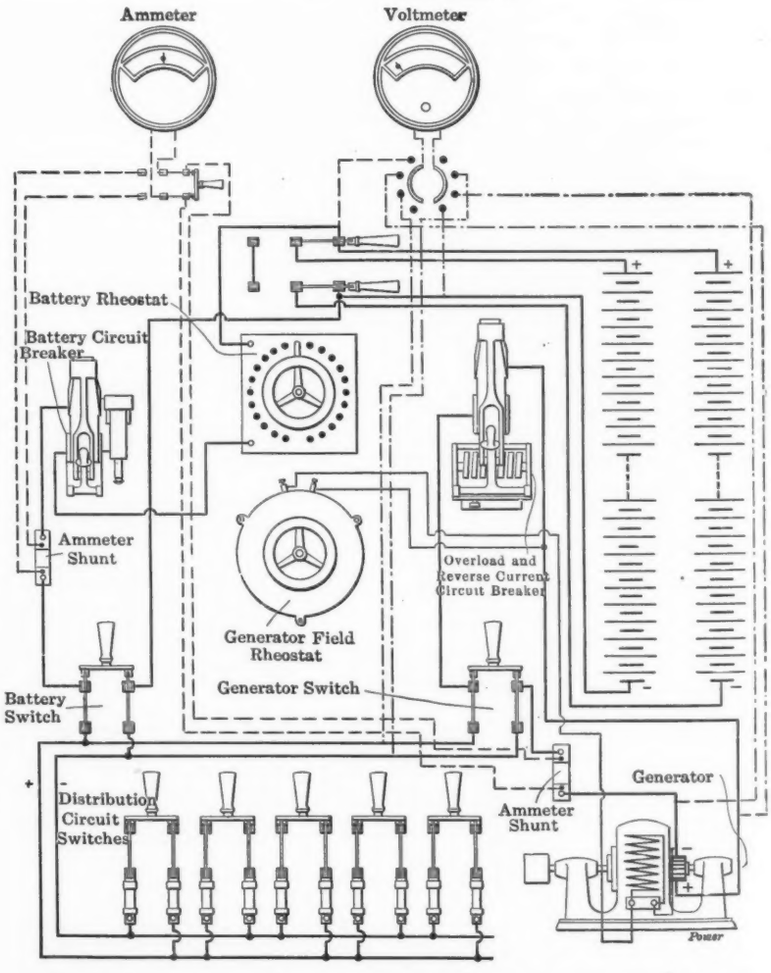


Fig. 3. Switchboard Connections for Generator, Battery and Distribution Circuits

Under ordinary operating conditions, it is desirable to maintain practically constant voltage on the lighting circuits, and as the voltage of a storage battery varies during discharge, methods have been devised to compensate for the changes in the battery voltage.

A fully charged battery which shows about 2.1 volts per cell standing idle will show, while discharging at an eight-hour rate, about 1.8 volts at the latter part of the discharge and somewhat less at higher discharge rates. To charge a battery fully it is necessary to raise the voltage, as the charge proceeds, from about 2.2 volts at the start to approximately 2.65 volts per cell at the completion of the charge. This is usually accomplished by a normal voltage charge with resistance control; a high voltage charge directly from the generator or by shunt-booster change, each of which methods will be explained later.

Size of Battery Required

In the selection of the proper battery, the number of cells is determined by the voltage of the system and is entirely independent of the size of the individual cells. Isolated plants of the various standard voltages require batteries of the number of cells in the following table:

Voltage of System.	Number of Cells.	Voltage of System.	Number of Cells.
110	60	220	120
115	64	230	126
125	70	250	138

The data throughout this article are based upon 110 volts, which is the voltage most used.

The size of the individual cell is determined by the amount of current to be supplied and the length of time it must be supplied on one charge. For ordinary purposes it is sufficiently accurate to estimate the energy taken by a 16-candlepower lamp as 55 watts and lamps of other candlepower on a proportionate basis.

Storage batteries are rated in ampere-hours, which is the product of the discharge current and the number of hours the discharge may be continued. The capacity of a battery at the eight-hour rate is considered normal, and if the discharge current is increased above the normal eight-hour rate the ampere-hour rate decreases, as will be seen by the following example:

Time of Discharge, in Hours.	Discharge Current; Amperes.	Battery Capacity in Ampere-Hours.
8	12.5	100
5	17.5	87.5
3	25	75
1	50	50

This means that 12.5 amperes may be obtained for eight hours, giving 100 ampere-hours, but if the discharge current be 25 amperes, it can be continued for only three hours, giving 75 ampere-hours; some additional capacity is, however, available at a lower rate.

On discharge at less than the eight-hour rate, the capacity of the battery is slightly greater, but the increase is small, and for ordinary calculations it is best to consider the capacity at rates lower than the eight-hour rate to be the same as the eight-hour capacity.

The size of a 110-volt battery can be approximately determined by the method indicated in the following example, the conditions being that the battery will be charged at any time during the day convenient to operate the generator and that the battery will be able to furnish current for lamps according to the above schedule.

Time.	Number of Lamps.	Amperes.	Number of Hours.	Ampere-hours.
5 p.m. to 10 p.m.	Twenty 16 c. p.	10	5	50
10 p.m. to 6 a.m.	Two 8 c. p.	½	8	4
6 a.m. to 8 a.m.	Six 16 c. p.	3	2	6
				60

The last discharge rate is three amperes, and there will be required a battery of sufficient size to furnish 60 ampere-hours at a three-ampere rate. This being less than the eight-hour rate, a battery is required having a normal rating of 60 ampere-hours.

The above example shows a condition where the full normal capacity of the battery is used in carrying the load. Under some conditions this is not possible, that is, where the latter part of the discharge is at a high rate.

Since the voltage of a cell varies from 1.8 at the end of a discharge up to about 2.65 at the end of a charge, a number of cells in series will produce a widely varying voltage across a line unless some regulating means is provided to compensate for the voltage change. The simplest method is by the use of a resistance in the battery circuit.

Rheostat Regulation

The simplest system of connections and that most frequently used in small plants is to arrange a battery of sixty cells divided into two sections of thirty each so that the sections may be charged either separately or in parallel through a rheostat. The object of this is to permit the cells to be charged with current from a 110-volt generator. Fig. 1 is an elementary diagram of this arrangement. While the battery is being charged, the series-parallel switches are kept in the position shown, with each section of the battery in parallel. When discharged the switches are thrown over to the opposite position which connects the halves in series.

The objection to this arrangement is that the loss of power in the charging rheostat, it being necessary to reduce the voltage by the rheostat from 110 to about 63 at the beginning, and to 79 at the end of a charge. This loss, however, does not necessarily occur except when the current is supplied to the lamps during period of battery charge. If no lamps are required at this time, it is possible to reduce the voltage of the generator to that at which the series resistance can be en-

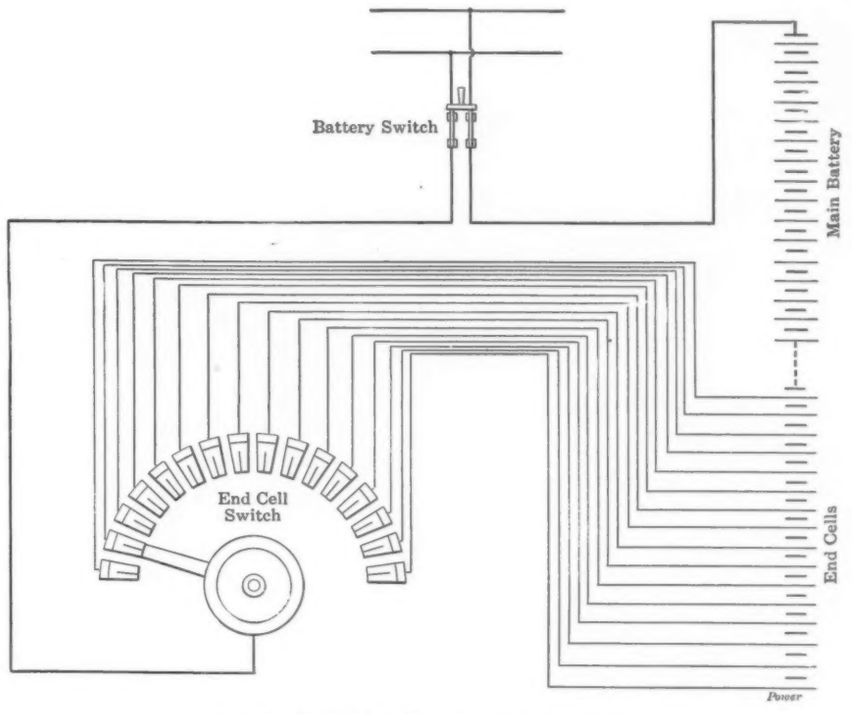


Fig. 4. End-cell Switch Connections

tirely cut out of circuit, leaving the battery connected directly to the generator; the charging current is then regulated by means of the generator field rheostat.

The voltage on discharge is regulated

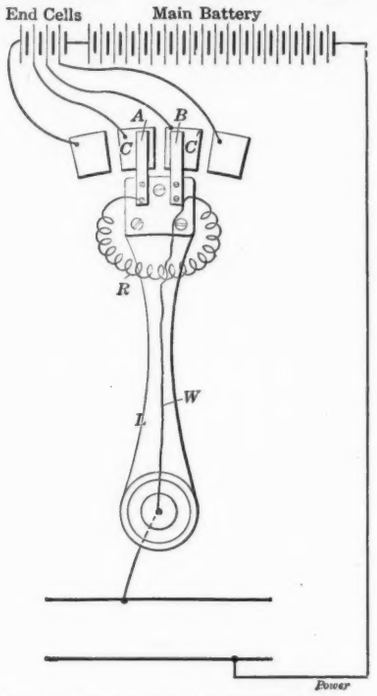


FIG. 5. DEVICE TO PREVENT SHORT-CIRCUITING END CELLS WHEN CUTTING IN OR OUT

by means of the same series resistance that is used in charging. The loss of power in this case is comparatively small, as the maximum drop in the rheostat is never more than 12 volts with a 60-cell battery on a 110-volt system.

Fig. 2 shows the diagram of connections of a switchboard designed for the parallel charge and series discharge with resistance regulation. This switchboard is adapted to plants where the generator is already installed and a battery is added to the equipment. The two single-pole double-throw switches permit the two sections of the battery to be connected in series for discharge and in parallel for charge or either half to be charged separately if desired.

Fig. 3 shows a similar type of switchboard for the control of both the battery and the generator. One ammeter is used to indicate both the battery and the generator currents as shown on the diagram. This is accomplished by having two shunts, one in the generator circuit and one in the battery circuit, the ammeter being connected to either shunt by means of a double-pole double-throw switch. The generator is protected by an overload circuit-breaker which has a reverse-current trip to prevent current from flowing from the battery through the generator. This switchboard, like the one shown in Fig. 2, is arranged so that the battery can deliver current to the circuit in parallel with the generator, which permits the use of a smaller generator equipment than would be possible without a storage battery.

END-CELL REGULATION

Another method of regulating the voltage of the batteries is to vary the number of cells connected in series. Thus, for a 110-volt circuit the number of cells required is $\frac{110}{1.8} = 61$. The number in series when the battery begins to discharge is $\frac{110}{2.5} = 44$. Therefore an arrangement must be provided whereby $61 - 44 = 17$ cells may be cut out or switched in one by one. These are called "end cells." In practice the number of end cells is less than the number obtained by calculation because the voltage of 2.5 is not maintained after the charging current is cut off. The number of end cells may be determined by the formula

$$N = \frac{E}{1.8} - \frac{E}{2.3}$$

in which E = the voltage of the supply circuit. Fig. 4 is a diagram of end cell connections.

In switching from one contact plate to the next, the circuit must not be broken, neither must the blade touch two adjacent contact plates at the same time as this would short-circuit the cell connected to these plates. All end-cell switches are therefore provided with an auxiliary contact, either on the moving blade or fixed adjacent to each main-contact plate. The main and auxiliary contacts are joined by a resistance but otherwise insulated from each other. The auxiliary contact touches one of the switch plates while the main contact touches the adjacent point. The circuit is therefore not interrupted, being completed through the resistance which has too low a value to affect the line potential appreciably. The resistance, however, is sufficiently great to prevent short-circuiting the cell con-

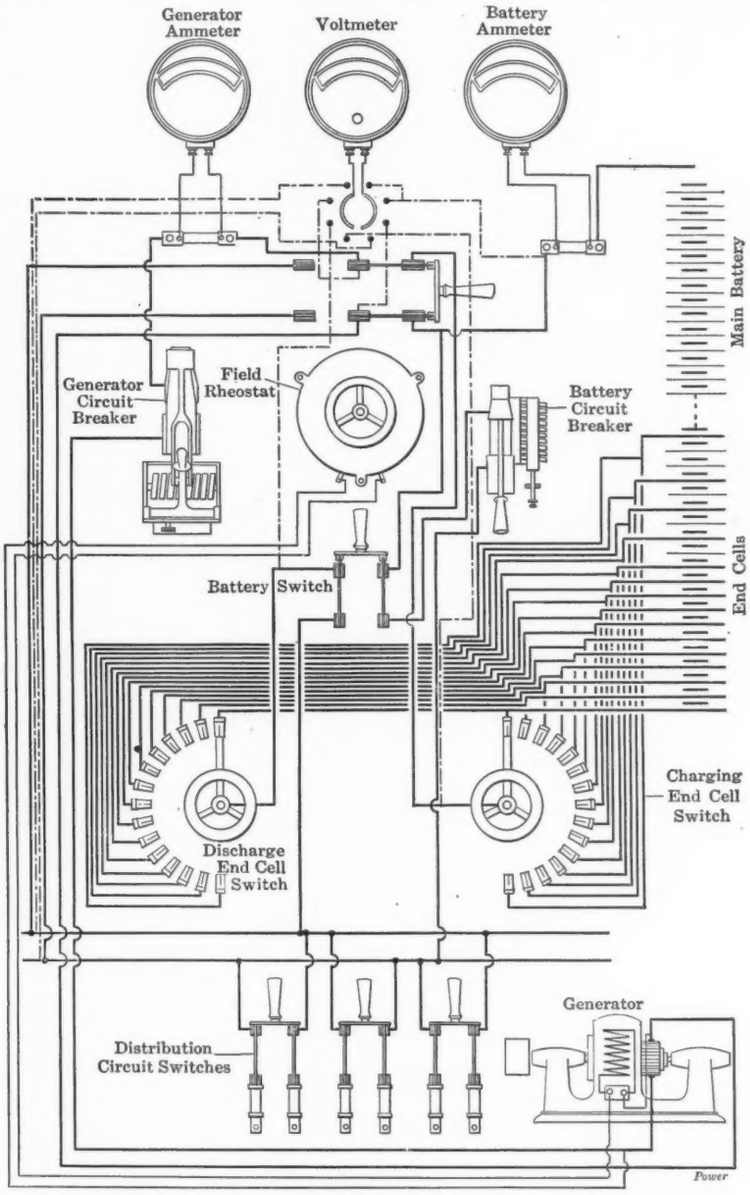


FIG. 6. COMPLETE SWITCHBOARD FOR CHARGING AND DISCHARGING THROUGH END CELLS

nected across the two plates. Fig. 5 illustrates the principle of this arrangement, though not the construction commonly used. The switch lever *L* carries two contact fingers, *A* and *B*, mounted on a block of insulating material *I* and connected to each other by a resistor *R*. The sketch shows the lever half-way between two "running" positions, the two fingers resting on different plates *C* and *C'*. At this moment the second end cell is connected to the terminals of the resistor *R* and the main circuit is connected directly to the plate *C'* by the main finger *B*. When the switch is moved far enough to the left to put both fingers on the plate *C*, the second end cell will be put in circuit and the resistor *R* cut out.

Since the end cells are gradually cut in as discharge proceeds, the main cells are discharged more than the end cells, the extreme cell being discharged least. While charging, all the cells are switched in and as the charge proceeds, the counter electromotive force of the cells increases, thereby cutting down the charging current. Consequently, it is advisable to cut out cells, one at a time, as the charge increases more and more. As the end cells were discharged less than the main cells, however, they become charged sooner, and therefore they are cut out, successively, beginning with the extreme end cell, which was discharged least. The connections of a switchboard arranged for high-voltage charge and end-cell discharge are shown in Fig. 6.

The battery is charged in one series directly from the generator, which has a voltage range to 155 volts, the charging current being controlled by the generator field rheostat. Two end-cell switches are required in order that the lighting circuits may be supplied while the battery is charging. The proper voltage for the lamps is obtained by adjusting the position of the end-cell switch connected to the lighting circuit. Two overload circuit-breakers are used, a simple one in the battery circuit and one with a reverse-current trip in the generator circuit.

Another method of voltage regulation is by means of counter electromotive force cells. These cells are connected in series with the operating cells with connections to an end-cell switch similar in every respect to the arrangement shown in Fig. 6, except that the end cells are connected so that their electromotive force opposes the battery electromotive force. As the battery voltage falls the end cells are cut out of circuit. This system is used only where the battery does not receive any attention while being charged. Since all of the battery cells are equally discharged they are all charged the same length of time, and it is not necessary to provide end cells to be gradually cut out as charge proceeds.

A 135,000 Volt Transmission System for Michigan

There is now under construction at Cook Falls, Mich., on the Au Sable river, a 9000-kilowatt hydraulic power station which is intended as the starting point of a 135,000-volt transmission system which will extend to Flint, 125 miles distant, and later to Battle Creek, 65 miles farther. The Cook Falls plant is the first of a series of four or five which, it is reported, will be established on the Au Sable river, and the available head there is about 40 feet. The generating equipment will comprise three 3000-kilowatt 60-cycle alternators mounted on horizontal shafts driven by waterwheels, with eight runners to each shaft. The voltage of these generators will be stepped up to 135,000 volts by delta-connected transformers installed at one end of the generator room.

The dam and power-house foundation will be of solid concrete with molded water passages and draft tubes. The power house will be of brick above the water levels, and will have a floor space 40x110 feet. The 40-foot dam will impound a lake covering 2000 acres, which will store water to meet the daily variations in the station load. The Au Sable river has an uncommonly uniform flow, averaging 1100 cubic feet per second. The records of ten years show that at no season has the flood flow exceeded four times the minimum. This regularity of flow is attributable to the springs, emerging from the clay strata underlying the sandy surface of the northern part of the peninsula, which supply the river; there are only two insignificant tributaries to the stream in its whole length above the water-power site.

The transmission line will be a single three-phase circuit of three No. 0 copper wires carried on suspension-type insulators hung from the cross arms of 55-foot tripod steel towers. These towers are generally similar to those of the 110,000-volt transmission into Grand Rapids. Two braced bracket arms extend from one side, and one arm from the other, carrying the wires at the angles of a tipped isosceles triangle with a 12-foot base and 17-foot sides. The lowest wire will be 40 feet above the ground. The suspension insulators to be used will have eight disks linked in series, each disk having been tested to withstand continuously 75,000 volts, and subjected to 100,000 volts for a brief period. Each complete eight-disk insulator measures 52 inches from the tower hook to the line conductor.

The annual per capita consumption of coal in the United States constantly increases. In 1880 it was 1.4 tons per capita; in 1892, 2.3 tons; and in 1907 it was 5.4 tons.

LETTERS

Rotary Converter Commutators and Rings — Switchboard Operators' Salaries

Referring to the question of the care of rotary-converter commutators and collector rings, which has been discussed considerably in this department, I have found that the best lubricant to use on commutators is kerosene oil. I apply a small rag soaked in oil and follow it with a dry clean rag. By keeping the one rag well soaked with oil and wiping until no more dirt comes off, the machine will run for six to eight hours without giving trouble. This should be done when the machine is first started, and the commutator is cool. If the brushes are hard it is sometimes necessary to use a little dynamo oil or vaseline.

With the collector rings, if the proper tension is kept on the brushes, and they have plenty of contact area, one application of a heavy body oil when the machine is first started should last for a twelve-hour run; but the brushes and rings should be well cleaned after each run. Of course, with soft rings it is almost impossible to keep them from cutting a little. The main thing is to have plenty of contact area and as little tension on the brush as it will stand without sparking.

I was interested in the article concerning switchboard operators in the July 5 issue. I think the rate of pay is much too low when the education and training necessary to make a good operator, are taken into consideration.

H. C. STIFF.

Chicago, Ill.

One of the telephone journals tells about a small independent telephone exchange near Columbus, O., which has had some trouble in the operation of its lines at night, owing to the proximity of the high-potential, alternating-current circuits of the electric-light company. It is said that, owing to the induction, it is almost impossible to hear over some of the telephone lines because of the noise, but the kindness of the electric company enables the telephone people to do some business in this situation. When a night call comes in for a physician, or any call which is believed by the operator to be urgent, she telephones the lighting company to shut off the supply of electricity in the village while the conversation is being held. With this request the electric-light company obligingly complies, and the conversation is uninterrupted.

Gas Power Department

Elementary Lectures on the Gas Producer*

By Cecil P. Poole

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men.

Making Gas from Coal

Coal consists of carbon, gases and one or two substances that will not burn and are commonly lumped under the name of "ash." If you make a hot fire and then dump fresh coal on top of the red-hot mass of burning coal, the heat will "distil" off the gases in the fresh coal and the carbon that is left will combine with the oxygen in the surrounding air, forming more gases.

This combination of carbon with oxygen is called "combustion" or burning, and if every atom of carbon unites with two atoms of oxygen, that constitutes complete combustion and the result is carbonic-acid gas, or carbon dioxide. The chemical formula for carbon dioxide is CO_2, meaning that the gas is composed of twice as many atoms of oxygen (O) as of carbon (C).

If the carbon in the coal cannot get into contact with more than equal parts of oxygen—that is, one atom of oxygen to each atom of carbon—then incomplete combustion is produced, and the result is carbon monoxide, represented by the symbols CO.

If the carbon unites with 1½ times as many atoms of oxygen as there are of carbon, then one-half of the carbon will be completely burned and the other half will be partially burned. This will produce both CO_2 and CO, but there will be 1½ times as much CO_2 as CO.

Now, if the CO_2 were passed into a bed of hot (not burning) coal, of the proper temperature, it would "pick up" another atom of carbon for each atom already in it and be changed to CO. On the other hand, since CO_2 is the result of complete combustion, it cannot be burned, and therefore will not unite chemically with oxygen.

Carbon monoxide, however, being the product of incomplete combustion, will burn, and if the CO produced in the process just described were brought into contact with more air, at a very high temperature, it would be burned and form CO_2 by uniting with the oxygen of the air.

When fresh coal is dumped on a hot fire, as described, the gases distilled out of the coal by the heat will either pass off into the atmosphere or be burned, according to the conditions immediately above the fuel bed. If the quantity of coal put on is not enough to deaden the fire and if sufficient air can get to the gases they will be burned.

All of the processes just outlined are carried on in a gas producer. Just above the grate the fuel is completely burned to CO_2; this is called the "combustion zone" (see Fig. 11). Immediately above this is a zone where two processes are supposed to go on; the excess air which was not used in the combustion zone unites with carbon to form carbon monoxide, and some of the CO_2 produced in the combustion zone also "picks up" carbon and is "unburned" to CO. This section is sometimes called the "partial combustion zone" and sometimes the "decomposition zone."

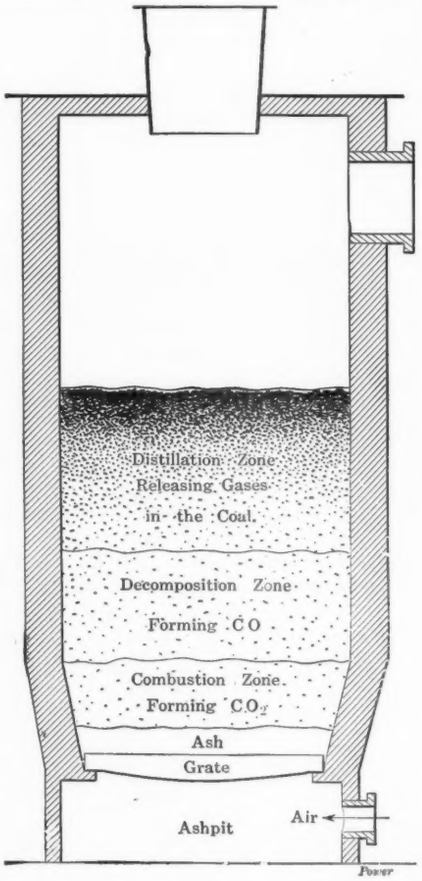


Fig. 11. Elementary Representation of Fuel Gasification, Using Air Alone

Above this is the "distillation zone" where the gases in the fresh fuel are distilled out by the heat in the gases coming up from the combustion and decomposition zones.

Fig. 11 is a diagrammatic representation of these zones and the processes which go on in them, as far as we have gone, but there is another process which goes on in most producers; that is the decomposition of steam into its component gases, hydrogen and oxygen. If air alone were admitted under the fuel bed of the generator, the combustion zone would spread to the top of the mass and the coal would simply be burned into CO_2; then the producer would be merely a stove and deliver only "dead" gases.

To prevent this, steam is admitted with the air, and the decomposition of the steam in the second active zone keeps the temperature down and prevents the combustion zone from spreading upward and burning all of the fuel completely. The oxygen of the steam combines with carbon in the second zone to form CO and the hydrogen goes on through and is taken out with the other gases.

It may be well to explain just here why "splitting up" a compound of gases causes a reduction of temperature. When carbon and oxygen unite to form either CO or CO_2, the heat in the carbon is liberated and it raises the temperature of the gases. Similarly, when hydrogen gas unites with oxygen to form steam (H_2O), the combustion liberates heat which raises the temperature. Now if either process is reversed, heat is absorbed instead of being liberated. Thus, if CO_2 is passed through hot carbon to form CO, some of the heat which was imparted to the carbon to make it "hot" is absorbed, and the temperature is reduced. Similarly, when steam is passed through hot carbon and "unburned" or decomposed into hydrogen and oxygen, as much heat is absorbed from the hot carbon as would be liberated by burning the same quantity of hydrogen. However, the oxygen combines with carbon to form CO, which liberates some heat, and the reduction of temperature due to decomposing the steam is partly neutralized.

For example, suppose that nine pounds of steam are decomposed, forming a pound of hydrogen and eight pounds of oxygen. "Burning" a pound of hydrogen into steam would liberate about 51,700 heat units; therefore "unburning" it will absorb about 51,700 heat units from the hot carbon. But the combination of the eight pounds of oxygen with six

*This is the third lecture of the series.

pounds of carbon to form CO will liberate about 26,700 heat units, so that the net result will be the absorption of about

$$51{,}700 - 26{,}700 = 25{,}000$$

heat units from the mass of hot coal in the second zone.

A mechanical illustration of the reversible heat process is afforded by the lifting and dropping of a weight. When a weight falls, energy is "liberated" and when it is lifted back to its original position, energy is absorbed by it. In other words, when a weight falls, work is done by the weight, and when it is lifted, work is done *on* it.

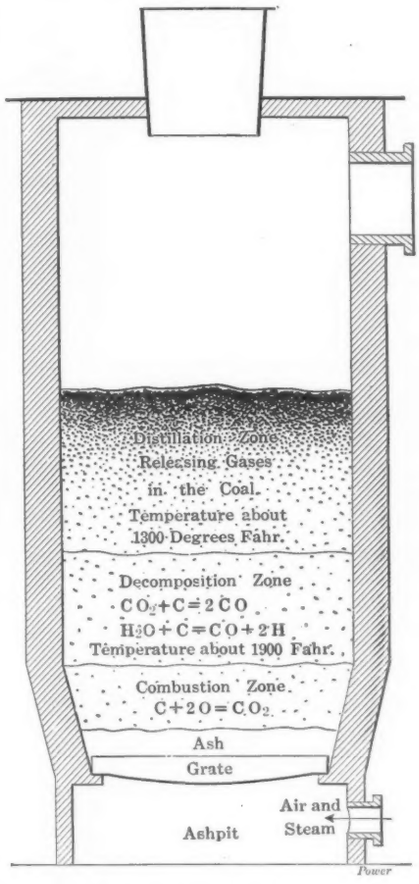


FIG. 12. APPROXIMATE CHARACTER OF THE ZONES OF A FUEL BED WHEN STEAM IS ADMITTED WITH THE AIR

Similarly, when any gas unites with oxygen, work is done *by* the gas—it raises the temperature of itself and the oxygen; when that same gas is separated from oxygen, work is done *upon* the gas—it absorbs energy in the form of heat. When carbon combines with oxygen it is necessarily in gaseous form, and is therefore considered as a gas.

Fig. 12 is an elementary diagram of the process of gasification of coal in a gas generator. It is the same as Fig. 11 with the addition of the effects produced by admitting steam with the air.

From what has been said it should be clear that while it is advantageous to send steam into the fuel bed along with the air, because it keeps the temperature down and permits continuous gasification, if too much steam is admitted the fuel bed will be cooled too much and the fire may be put out entirely. Even if that is not done, an excess of steam may reduce the temperature to such an extent that the production of carbon monoxide (CO) is greatly reduced and the operation of the generator impaired.

The question of operating temperatures will be fully discussed in a future lecture.

CORRESPONDENCE

Gas Engine Reliability and Economy

The June 28 number of POWER contained a very violent criticism by R. L. Paton of Mr. Beattie's article in a previous number. I find much in Mr. Paten's letter that is such rank injustice to the gas engine that it demands a reply.

Mr. Paton states that the gas engine is not as reliable as an electric motor but has established a reputation for unreliability. This one sentence shows that he has much to learn about a gas or gasolene engine. The charge is not true of engines built during the past ten years. It might have been true twenty years ago when this type of prime mover was in its swaddling clothes, but it has been doing more to live down its "past" than any other system ever has and at the present time can hold its own with any power source now available.

In court an expert witness has to qualify before his testimony is heard. Mr. Paton has handed out testimony without stating his experience. I will endeavor to "qualify" by stating that I have spent ten years with the gas engine as salesman, erecter and repairman with some of the largest engine makers in this country, but I am not connected with any of them now. My experience has not been confined to one town or city but spread over a large area.

I have seen many engines that were from twelve to fifteen years old doing daily work honestly and satisfactorily. I have found them working in plaster mills, sawmills, bakeries, blacksmith shops and other places where they were covered with dust, ashes or dough. The majority of them are run and cared for (?) by ignorant, unskilled laborers who do not know enough to oil a wheelbarrow when it squeaks. There are thousands of towns in this country that depend on the internal-combustion engine to supply them with water. There are hundreds of engines that are started in the morning with a measured supply of fuel and lubricating oil and left to run unattended until the supply is exhausted. This is the regular practice in many places. How many would or could pursue that method with a steam plant? I would ask Mr. Paton if he knows that there are thousands of gas engines that run from Monday morning until Saturday without a stop. In many of these plants an accidental stop would mean a loss of hundreds, and in some cases thousands, of dollars. There are engines that run three and four months night and day without stopping. Can anyone ask for any more reliable service than that?

Under equally good care, the gas engine is fully as reliable as a steam engine or an electric motor and will stand more abuse and neglect than either of them.

As regards operating cost, the gas engine will run for less than two cents per horsepower-hour, which would be equal to about 2½ cents per kilowatt-hour for electric power. As the average cost of current is from six to eight cents per kilowatt-hour, it can be easily seen that the gas engine is by far the cheapest power, even with city gas at 90 cents per 1000 feet.

H. K. WILSON.

New Bedford, Mass.

A Cure for Porous Gas Engine Cylinders

If the iron of a gas-engine cylinder is the least bit porous, more or less water is likely to seep through the water jacket wall into the cylinder, while the engine is standing idle for a considerable length of time, and this will make it very hard to start the engine. A remedy that is sometimes applied to porous cylinders is to fill the water jacket with a solution of copper sulphate or a solution of salammoniac, and allow it to stand over night. The next morning the solution is drained out and the water jacket is washed out with clean water. The copper sulphate or salammoniac, as the case may be, penetrates into the pores of the cylinder wall and causes a rusting action which fills the pores with a hard cement of iron rust, and this prevents any water from seeping through the wall into the cylinder when the engine is standing idle.

HOWARD M. NICHOLS.

Parnassus, Penn.

It is proposed in a patent issued to S. R. Bergman to improve the starting torque of a squirrel-cage induction motor by providing two end rings in parallel, one of low and the other of relatively high resistance. A laminated iron ring mounted on the rotor shaft is so arranged that it can be shifted to or from the low-resistance end ring and in this way vary the reactance of this circuit. When starting, the reactance of the low-resistance circuit is a maximum, and more current will be carried by the high-resistance ring than by the low-resistance ring, thus reducing the total current and increasing the torque.

Measuring Contents of Tanks

By F. L. Johnson

Simple directions for making chart and measuring stick that will show the contents of horizontal cylindrical tanks in gallons, feet or pounds.

Because the calculation of the area of a segment of a circle involves processes which are outside the realm of pure arithmetic, many engineers balk at problems in which segmental areas are a factor. In gas works, oil refineries, and in power plants where liquid fuel is burned in the engine cylinders or under the boilers, the oil or other liquid is most commonly stored in horizontal cylindrical tanks and as an exact knowledge of the quantity on hand at any time or the amount used from hour to hour or from day to day is of no little importance to the engineer, he seeks for a method by which the contents of a tank of any diameter and length with any depth of oil may be readily and accurately calculated.

If the containing tank were rectangular or circular and stood on end, its contents could be easily ascertained by multiplying the area of the base by the depth of the liquid, and as finding the areas of rectangles and circles is a comparatively simple matter, the problem would be simple. But when the circular tank lies on its side the problem becomes an intricate one involving calculus, for the ratio of content to its depth varies with every change in depth, and unless some short cut can be made the process is one so tedious that the ordinary man shrinks from attempting it, and instead makes a rough estimate of the contents.

If it is remembered that all areas are proportional to the squares of the length of their corresponding lines, and decimals are understood, a short time spent on the table of segmental areas to be found in most engineer's pocketbooks will enable anyone to prepare a table, chart or measuring rod, which will show at once the cubical contents in pounds, gallons or cubic feet of a horizontal cylindrical tank of any dimensions.

In this process the first step is to find the area of the segment of a circle the diameter of which is unity. This area is found by the use of the accompanying table.

It will be noticed that one of the columns in the table is marked hight and the other area, which means that the segment, the hight of which corresponds to the fraction found in the hight column, will have the area found opposite it in the area column, when the diameter of the circle is unity. The fraction in the hight column is obtained by dividing the hight of the segment by the diameter of the circle of which it is a part.

To use the table for finding the area of the segment of any circle divide the hight of the segment by the diameter of the circle and multiply the area found in the table opposite the resulting fraction by the square of the diameter of the given circle.

For example, the hight of a segment is 9 inches and the diameter of the circle is 6 feet, what is the area of the segment?

Dividing 9 by 72 gives 0.125. Looking in the table the fraction 0.125 is found opposite the number 0.056664 in the area column and is the area of the segment when the diameter is unity; but the diameter of the circle is not unity but 72 inches, or 6 feet. As it has been remembered that all areas are proportional to the squares of the length of their corresponding lines, it is seen that if the number denoting the area found in the table be multiplied by the square of 72 or of 6 the area of the segment of the given circle will be found in square inches or in square feet, according to which dimension is used in the calculation.

Having mastered the process of computing the areas of segments by the use of the table the utilization of this knowledge in finding the contents of partially filled tanks is an easy matter as the area of one end of any regular body multiplied by its length gives its cubical contents.

TABLE OF AREAS OF SEGMENTS.

Hight.	Area.	Hight.	Area.
0.005	0.000471	0.255	0.157891
0.01	0.001329	0.260	0.162263
0.015	0.002438	0.265	0.166663
0.02	0.003749	0.270	0.171090
0.025	0.005231	0.275	0.175542
0.03	0.006866	0.280	0.180020
0.035	0.008638	0.285	0.184522
0.04	0.010538	0.290	0.189048
0.045	0.012555	0.295	0.193597
0.05	0.014681	0.300	0.198168
0.055	0.016912	0.305	0.202762
0.06	0.019339	0.310	0.207376
0.065	0.021660	0.315	0.212011
0.07	0.024168	0.320	0.216666
0.075	0.026761	0.325	0.221341
0.08	0.029435	0.330	0.226034
0.085	0.032186	0.335	0.230745
0.09	0.035012	0.340	0.235473
0.095	0.037909	0.345	0.240219
0.10	0.040875	0.350	0.244980
0.105	0.043908	0.355	0.249758
0.110	0.047006	0.360	0.254551
0.115	0.050165	0.365	0.259358
0.120	0.053385	0.370	0.264179
0.125	0.056664	0.375	0.269014
0.130	0.059999	0.380	0.273861
0.135	0.063389	0.385	0.278721
0.140	0.066833	0.390	0.283593
0.145	0.070329	0.395	0.288476
0.150	0.073875	0.400	0.293370
0.155	0.077470	0.405	0.298274
0.160	0.081112	0.410	0.303187
0.165	0.084801	0.415	0.308110
0.170	0.088536	0.420	0.313042
0.175	0.092314	0.425	0.317981
0.180	0.096135	0.430	0.322928
0.185	0.099997	0.435	0.327883
0.190	0.103910	0.440	0.332843
0.195	0.107843	0.445	0.337810
0.200	0.111824	0.450	0.342783
0.205	0.115842	0.455	0.347760
0.210	0.119898	0.460	0.352742
0.215	0.123988	0.465	0.357728
0.220	0.128114	0.470	0.362717
0.225	0.132273	0.475	0.367710
0.230	0.136465	0.480	0.372704
0.235	0.140689	0.485	0.377701
0.240	0.144945	0.490	0.382700
0.245	0.149231	0.495	0.387699
0.250	0.153546	0.500	0.392699

The table gives the areas of 100 segments from 1/200 to ½ of the diameter in hight. But only for certain diameters would any of the hights be found in even inches, but this is of no importance as the rod with which the hight of segment is measured may be graduated in fractions of the diameter instead of in inches, or the areas for even inches or half inches in hight may be calculated and inserted in the table.

If a measuring rod of a length equal to the diameter of the tank be marked off into 200 equal spaces and marked from both ends toward the middle with numbers corresponding with the fractions representing hight in the table, then if the tank is one-half or less full, the reading will tell the hight of the segment of liquid. If more than half full it is the hight of the empty space that will be measured.

It is not necessary in these calculations that the dimensions in inches or feet enter into them at all except when the diameter of the tank is squared.

To make a chart which will show the contents at any time, or the quantity drawn out during any period, make a column of numbers corresponding to those on the suggested measuring rod, calculating the area of each segment in square inches or square feet as desired and multiplying it by the length of the tank for the volume.

When 100 computations have been made, repeat them in inverse order.

To use the chart, measure the depth of liquid in the tank with the graduated rod. If the tank is more than half full the number on the rod referred to the chart will give the contents of the empty space above the liquid, which, subtracted from the volume of the tank, will show how much remains. If the tank is less than half full the reading will be the quantity in the tank and the difference between any two readings will show how much has been taken from or added to the contents between the measurements.

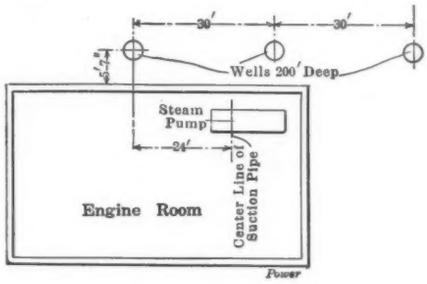
On the measuring rod the chart itself may be made by putting the figures denoting the contents on the side opposite the one denoting the hight. Or the rod may be made square with the hight on one face; contents in cubic feet on the second, in gallons on the third and the fourth side may be graduated in inches, or if the specific gravity is constant the weight in pounds for each graduation may be calculated and marked on the rod instead of some other measure of capacity.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words, wanted.

Pumping Layout for Criticism

I should like opinions as to the proposed plan for pumping water from artesian wells which is shown in the accompanying sketch. It is proposed to install one steam pump in the engine room to draw water from all three wells simultaneously and discharge into a tank 75 feet above the ground. We hope to draw 75 gallons per minute from each well. Will one pump do the work or must there be a separate pump for each well? Would compressed air be more satisfactory and how will compressed air



PUMPING LAYOUT

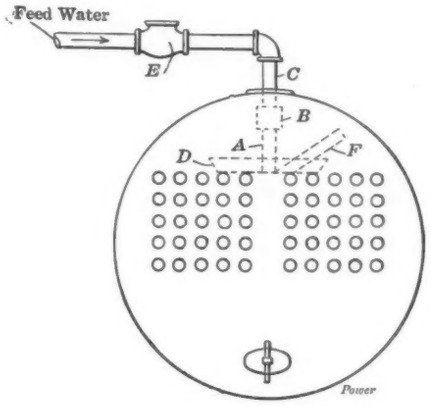
compare with the steam pump for economy? How many cubic feet of free air per minute will be required to do this work, taking air at 90 pounds gage?

H. B. FILLMEN.

Pottstown, Penn.

Water Hammer in the Feed Line

A few days ago a very sharp water hammer suddenly developed in the feed line of one of our boilers. The sound



DISPLACED FEED PIPE

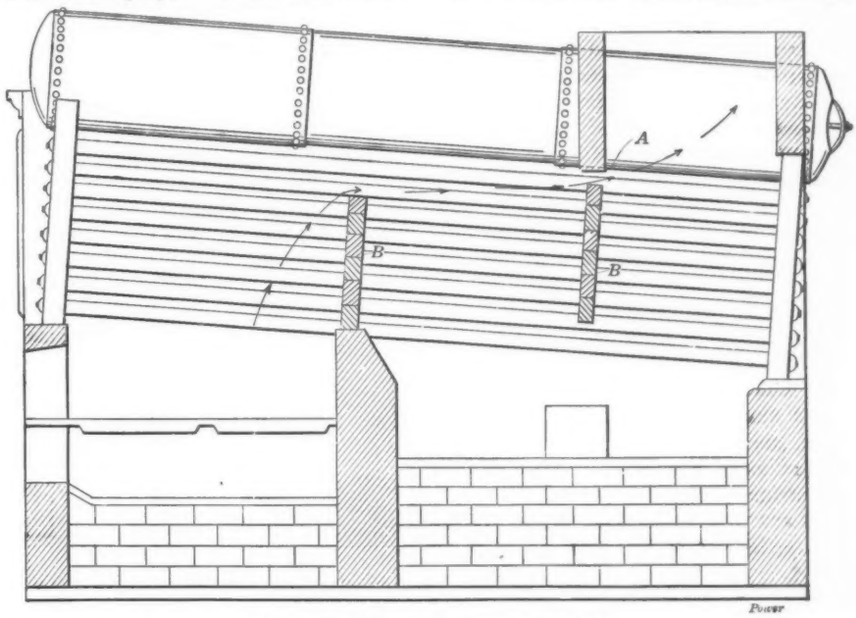
seemed to come from a point near the elbow and in a few minutes the top of the check valve *E* began to work loose and leak. We could not spare the boiler until Sunday (two days off) so we had to keep an eye on the check valve and continue running. Saturday about 9 a.m. the nipple *C* split from the boiler shell and it was with much difficulty that we were able to make the balance of the run. On cutting out the boiler we found that the pipe *A* had worked out of the coupling *B* and had fallen over into the position *E* in the pan *D*, whose mission it is to keep the lower end of pipe *A* submerged and prevent water hammer. A new nipple was inserted and we had no more trouble.

R. M. ORR.

Brantford, Ont.

Why the Boiler Would Not Steam

The accompanying sketch shows the elevation of a water-tube boiler, two of which were installed in a plant where the writer was employed. These boilers were



ROW OF BRICKS OMITTED AT "A"

300 horsepower each. When No. 1 boiler was put in commission it was found to be satisfactory in every way, but when No. 2 boiler was fired up and put in commission and No. 1 cut off, it was impossible to carry the load with No. 2 and No. 1 had to be cut in again. As the boilers were exact duplicates, No. 2 was cut out and cooled down and a search made to locate the trouble.

It was finally located at the point marked *A*. When the boiler was erected the top row of baffle bricks *B* was not put in at *A* which allowed part of the heat to pass direct to the stack as indicated by the arrows. This small opening reduced the effective heating surface to such an extent that the boiler would not carry half of its load. After the baffle was repaired the boiler gave satisfaction and was accepted.

This was a good object lesson, and showed the importance of having all baffles properly put in, as a small opening has a greater effect upon the steaming capacity of a boiler than is generally supposed.

R. L. MOSSMAN.

Tampa, Fla.

Dismissal without Cause

Some time ago a young engineer accepted a position in a fairly large plant because the pay was better than that which he had been receiving. His watch was from 4 p.m. till midnight and an oiler came on every night at 5 p.m. and worked till 6 a.m.—a part of two engineers' shifts. The duties of this engineer were to look after four engines and generators, one blower unit and one ice machine, doing his own oiling from 4 to 8 p.m. and helping out in the boiler room whenever necessary. The conditions

were such that the ice machine had to be shut down every day from about 3 to 7 p.m. to enable the generators to carry the load. Therefore, this young engineer almost always found the ice machine shut down when he went on duty.

One day after he had been there a short time, he noticed several men coming into the engine room and asking for the chief, they having seen an advertisement in a paper for an engineer at this plant. Supposing that he was to lose his job, the young engineer went to the chief and asked for explanations; he received the following reply: "You seem to know your business and you are a good hard worker, but you are just hoodooed, that is all." Of course, the assistant laughed and insisted upon a further explanation. The chief then gave it without hesitation. He said, "Well, too many things have happened to you in too short a time. First, this bearing warming up, then the square end of that suction-valve stem breaking off and also the burning of the leather cups in the stuffing box of the ice machine; all happening within 4 days. I do not blame you so much but you are just hoodooed, that is all." Not a very good reason to discharge a man for, who "knew his business and was a good hard worker."

Now I am in a position to explain these three happenings, for I am the young assistant engineer referred to.

First, the warm bearing was on a large high-speed engine at the back of which was being dumped all the material for the erection of two water-tube boiler foundations, the dust of which settled all over the engine. The bearing had run for one day and it was impossible to shut the engine down on account of the load. I discovered the warm bearing myself, cooled it and ran the engine through. It is still running.

Second, upon first taking the position, I found the square end of this valve stem twisted about one-half way around, someone having been in the habit of putting a wrench on the valve to open or close it. I started to open the valve after pumping the gas out of the machine and the square end twisted off. The engine was still turning over slowly and the low-pressure gage hand was moving, so I knew the valve was either open or was leaking badly. I let it run and found that the machine had been shut down, the discharge valve closed and the suction valve left open, a poor practice in refrigeration. I reported all conditions and what I had done to the first assistant, he being the man whom I relieved.

Third, on the day the cups were burned the ice machine was running when I went on. After feeling all the bearings in the main engine room, I went to the ice-machine room to look at conditions there. It was 4:10 p.m., just 10 minutes after starting to work, and I found the rod blue and hot. I gave the machine more gas and let up on the stuffing-box gland and remained right with it till it began to cool off, then called the attention of the first assistant.

I am not writing this with any malice toward anyone as I was lucky enough to get a position nearer my home and working six days a week at the same salary for which I had been working seven. But I should advise all engineers to make a thorough inspection of the whole plant, both upon going on and off duty. And I hope my experience will teach some chief engineers to go to the bottom of everything before discharging anyone.

R. P. WILCOX.

Chicago, Ill.

What Causes the Vibration?

We have two 72-inch by 18-foot return-tubular boilers carried on Gallus frames. The service is such as to require only one boiler to be operated at a time. No. 2 boiler gives no trouble whatever, but when No. 1 is used, violent vibrations are set up in the boiler and in the steam piping. Unless the engine is throttled so as to wiredraw the steam, the vibration is as great at no load as at full load.

The accompanying diagrams show the layout of piping, and the writer would be pleased to note the opinions of POWER

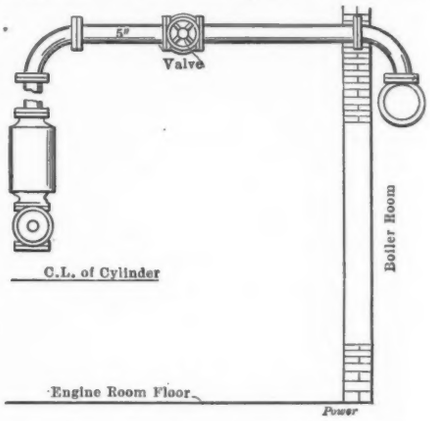


FIG. 2. ELEVATION OF ENGINE-ROOM PIPING

readers as to the probable cause of the trouble.

E. S. DAVIS.

Logan, O.

Pump Problem

Will some reader of POWER kindly solve the following problem? What will be the necessary steam pressures in the high- and low-pressure cylinders of a 10, 16 and 8 by 18-inch compound boiler-feed pump, working against 185 pounds boiler pressure at 35 strokes per minute?

W. E. THOMPSON.

Redondo Beach, Cal.

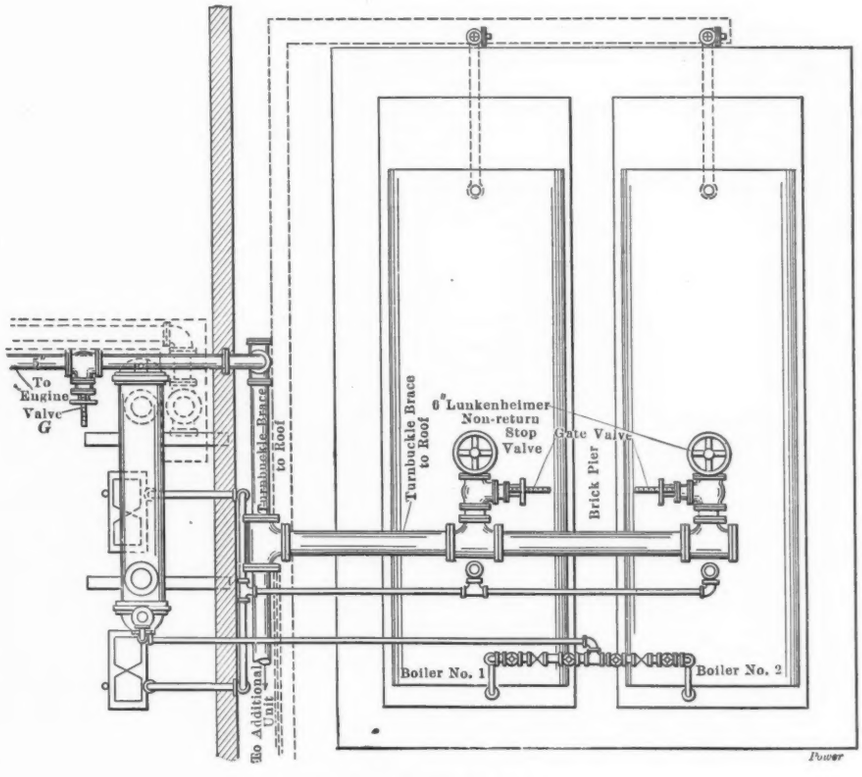


FIG. 1. PLAN OF PIPING FROM BOILERS

The piping is suspended, for the most part, by turn-buckle hangers secured to the roof. The engine is a 14x16-inch single-valve Fleming, running at 225 revolutions per minute.

Finding Areas of Irregular Figures

For irregular figures where a planimeter is not available, but where a laboratory balance is, areas may be obtained with a considerable degree of accuracy by cutting the diagram out, together with a unit area of 1, 2 or 4 square inches from the same sheet of paper, and weighing the two pieces of paper thus obtained; the areas being proportional to the weights. In cases of very broad lines bounding the diagram, it is better to trace the figure on another piece of paper, following the center of the bounding line, in order to get rid of the weight of the ink.

DONALD M. LIDDELL.

Grasselli, Ind.

Operating Mechanical Tube Cleaners

There are different methods of keeping boilers free from scale; some use filters and open heaters, thereby preventing the scale-forming matter from entering the boiler; others use compounds to nullify the scale-forming tendencies, while still others let it form and then get busy with kerosene, soda ash and a mechanical tube cleaner.

For the benefit of those using the latter method, I will relate my experience. Our boilers are of the horizontal tubular type, 6x18 feet with ninety-two 2-inch tubes. The feed water is taken from a mountain stream that runs over limestone rocks. There are no filters and the feed water is heated only to 140 degrees before entering the boilers. We run 24 hours per day and during the winter months have no boiler to spare for the purpose of cleaning. Consequently, by spring the boilers are full of scale. We tried a compound but even with frequent blowing down could remove but little. As the mud always accumulated just over the bridgewall, it was considered more dangerous than the scale; hence a mechanical cleaner was procured.

The company took the stand that the cheapest man in the plant was all right to run it, it not making any difference whether the man knew that continuous hammering will make an iron bar become thinner, and that if steam were kept on the cleaner, it was necessary to keep it moving along the tube; for if this were not done, the tube would be stretched, made thinner, and covered with small bulges, which would tend to weaken it.

So the ash shoveler was put to work cleaning the first boiler. After he had finished, the boiler was filled and steam gotten up. When it had been cut in a couple of hours, the fireman reported it to be taking too much water. I told him that was because it was clean and pointed out the economy of a clean boiler. When the load went off on Saturday night, this boiler was the first to have its fire drawn, and the fireman reported that it was taking just as much water as when making steam. I accordingly opened the combustion-chamber door and looked in. It had the appearance of a waterfall—most every tube was leaking. We had to replace seventeen out of the ninety-two tubes. Those which were taken out had bulges all over the surface.

I placed one of them across two horses and sent for the boss. When he arrived I put the mechanical cleaner in the old tube, turned on the steam and held it in one place about a second; the outside of that part of the tube immediately began to swell. The boss said, "That is enough, we will use it no more." But I told him it was not the fault of the cleaner but of the man who used it. I then proceeded to run it up and down the tube without injuring it. Since then the ash shoveler has not been allowed to run the mechanical tube cleaner but we allow him to use the scraper.

GILBERT GUÈRIN.

Adams, Mass.

Trouble with an Oiling System

For the benefit of those engineers who have not had experience with continuous lubrication I will relate some of my experience during the past year. The plant contains two direct-connected high-speed units, each of 100 kilowatts capacity. The engines are of a popular make and are doing satisfactory work. I took hold of them the day after they were delivered to the owners and thought I had drawn a prize. The oiling is from a gravity tank bolted on the top of the frame and feeding through sight feeds to the various bearings. After doing its work, the oil drains back to a small filter attached to the subbase and from there is pumped back to the tank. This cycle is continuous while the engine is in operation. The pump plunger is driven from the valve stem of the engine and consequently the stroke varies every time the load affects the cutoff. Right here has been all the trouble with the system. This may not appear to be of much importance, but when a person sees the oil in the tank getting continually lower, without being able to make the pump take hold, it naturally makes him anxious.

It was a cold day when I first took charge of the plant. The engine started off smoothly and the oiling system worked nicely for about an hour, then it began to fail. I tried all the things I knew and by keeping at it persistently got through the day without losing all the oil in the tank. The following day the other unit was used and worked without a hitch; it has done so ever since with absolutely no trouble, but I have had many unhappy moments with the first one. Some days it was all right, on others it was all wrong.

When the weather became warm, however, the pump worked as well as one could wish. This gave me the clue. In cold weather the temperature of the part of the room in which this engine was located had been low enough to cool the oil to a point where it would not flow fast enough to fill the pump at the speed the plunger was moving.

While all this was happening I was having trouble with the packing on the plunger. It would remain tight for a few days and then all at once would start leaking. On removing the plunger it was found to be badly worn. I had a new one made and after assembling, packed the pump with the hardest wick packing obtainable, in place of a good grade of soft wick formerly used. Since this was done there has been little trouble with the pump and the engine room can be five to ten degrees cooler than before.

G. F. BARKER.

Dorchester Centre, Mass.

Rumbling in Boiler

I have charge of a battery of boilers, one of which acts very much out of the ordinary. In the morning before starting, the pressure runs up until the safety valve, which is spring loaded, begins to sizzle; immediately there is a rumbling noise inside the boiler that sounds like a jet of steam in cold water. There is a trembling of the boiler, and the steam-gage hand drops gradually from 128 to about 90 pounds and then returns to 128. It happens every morning, and I cannot account for it, and though I have had charge of steam plants for fourteen years I never before saw anything like it.

M. H. TARBELL.

Cincinnati, O.

Packing a Feed Pump

Will someone kindly advise me as to the best method and materia' for packing the plunger of a boiler-feed pump handling water at 100 to 195 degrees Fahrenheit against a boiler pressure of 150 pounds? I have experienced considerable trouble with our pumps, two weeks being the longest period that any packing lasted.

GEORGE KRAMER.

New York City.

It is reported that the town of Windsor, Ont., has decided to purchase electric power from Niagara. The 110,000-volt line to London, Ont., will be extended over the 108 miles separating Windsor from this city. The expense of building the line to the city limits will be paid for by the Canadian government. Windsor, which is a small town, cannot use more than 2000 horsepower, but it has contracted to sell a large share to the city of Detroit, which is directly across the river.

Questions Before the House

Steam Tables

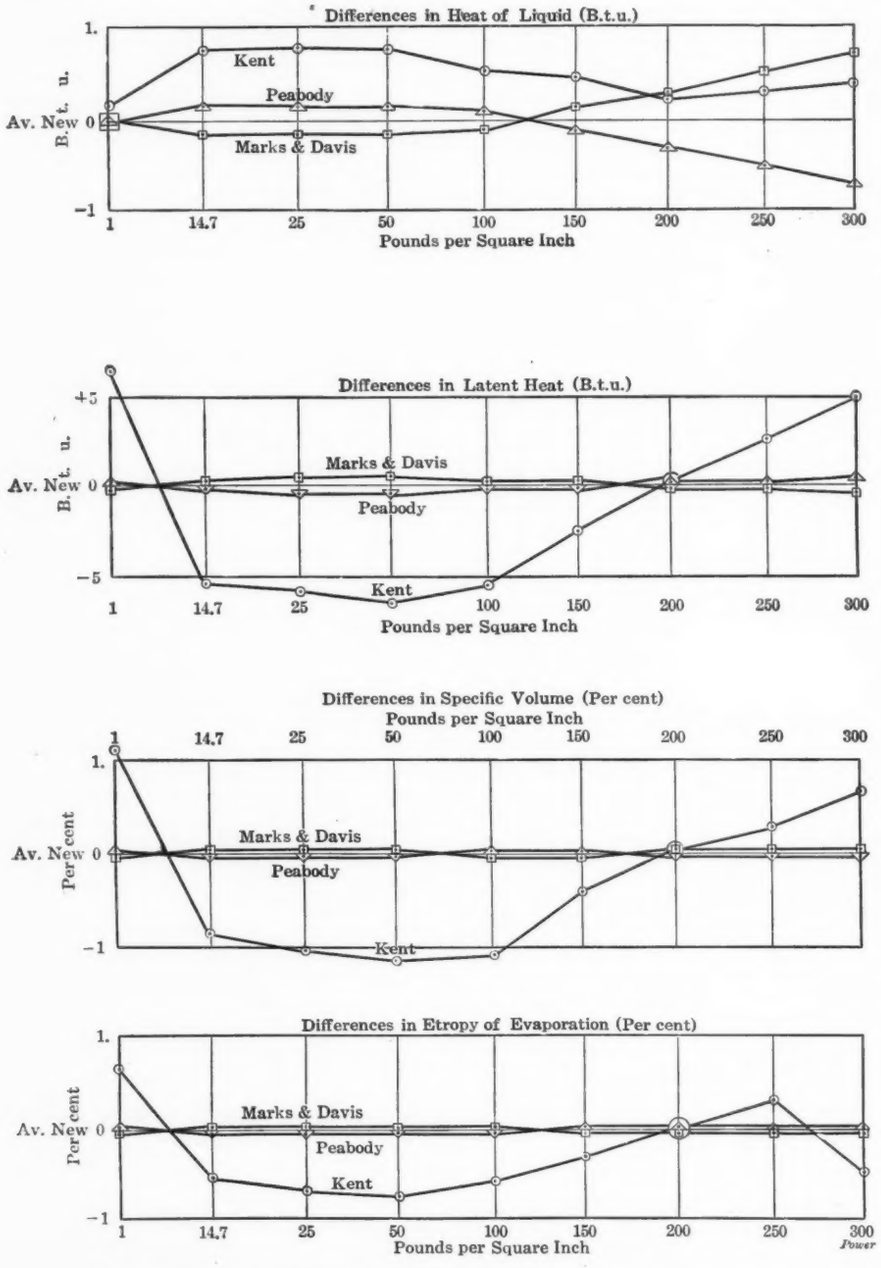
The accompanying chart of relative differences of values is taken from steam tables, old and new, showing how the latest tables differ from those which have been long in use. The new tables of specific volumes that were published in a recent issue of POWER may make this of interest to some of the readers.

In each case the base line for the curves is taken as the mean of the values in the tables by Marx and Davis and by Peabody. The differences are laid off below the mean when of less value than the mean and above when greater than the mean. As is shown, the new values of the specific volumes and entropy of evaporation are substantially in agreement, while the heat of the liquid and the latent heat show a considerable divergence.

DONALD S. SAMMIS.

Stratford, Conn.

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues.



COMPARISON OF NEW STEAM TABLES (PEABODY-MARKS-DAVIS) WITH OLD STEAM TABLES (KENT-1905)

Central Station versus Isolated Plant

The never-ending discussion of Central Station versus Isolated Plant seems to be very much alive in some of the recent issues of POWER, with the general result that, "A man convinced against his will is of the same opinion still."

With no hope, therefore, of its having any other effect than to add perhaps a little fuel to the flames, I will take exception to that particular part of the argument which is based on the fact that central stations charge large consumers three or four cents less than an average price, and small consumers three or four cents more.

Electric current is a commodity which is made and sold on much the same basis as any other commodity. Those charges which go to make up more than 50 per cent. of the net cost are directly affected by the amount of current delivered to one consumer. It is exactly the same reason which makes it possible for an isolated plant of large capacity to produce current at a price per kilowatt-hour less than that for which it can be produced in a small plant.

If the large consumer is to be forced by law to pay anything like the price paid by the small consumer for electric current, then he should be forced to do likewise with every commodity which he buys, whereupon our socialistic friend will find considerable fault with his living expenses increasing somewhat more than they have already.

The statement has also been made that certain isolated plants produced current so cheaply that the central-station supply would have to be charged for at the rate of ¼ of a cent per kilowatt-hour. It would be interesting to see by what process of figuring any kind of a plant to produce electric current can be installed at a price the fixed charges on which would be as little as ¼ of a cent per kilowatt-hour.

The writer has designed and installed many isolated plants under conditions both favorable and unfavorable; but he has yet to hear of one the investment in which alone represented a fixed charge

of less than ¾ of a cent per kilowatt-hour, although he has ben assured by many manufacturers of apparatus that it was very customary to find plants in which the fixed charges were less than ½ of a cent per kilowatt-hour. Persistent inquiry has failed to reveal where these plants are located. The writer is still obliged to believe that the experience of engineers in general will not substantiate any such statements.

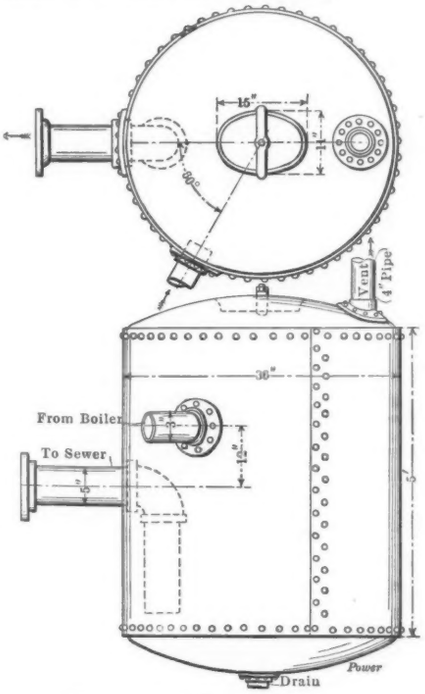
The foregoing is not intended to convey the idea that the writer does not believe that isolated plants cannot compete with central-station service in some instances; but it is intended to convey the idea that central stations approach this question with a large amount of accurate information to back up their statement, and that they are not inclined to either "bulldoze" or "hypnotize" the consumer into signing a contract which is distinctly to his disadvantage. The consumer always has the privilege of going out and employing a competent engineer to analyze central-station figures; and consequently does not need much sympathy if he does not show the same acumen in regard to this item of running expense as he does in purchasing his other supplies.

WARREN B. LEWIS.

Providence, R. I.

Accident to Blowoff Tank

In the May 17 issue of POWER, E. H. Long describes a blowoff tank which failed at a hotel in Kansas City.



SHEET-IRON BLOWOFF TANK

In my estimation the manner in which the tank was connected was responsible for the accident. His sketch shows the blowoff pipe from the boilers entering the tank near the top and continuing downward inside and the overflow to the sewer leaving at about the same level. I think that these two connections should have been reversed.

If the water in the tank is hot, due to a leaky blowoff valve or some other cause, there will be a vapor present in the tank above the water. Now, if the pressure is even slightly increased by starting to blow down, the vapor is immediately condensed and there is nothing left for the water to compress, and thus form a cushion. The result is a water hammer in the tank, which is liable to crack or break the cover.

I submit a sketch of a blowoff tank which I am about to install. This tank is special, and is to replace a tank which failed in the same way as did the one Mr. Long described and cost the life of my predecessor.

The shell is made of ⅜-inch sheet iron and the heads of ½-inch material. The cost is less than that of a cast-iron tank.

I would be glad to have POWER readers criticize my design.

R. E. COOPER.

Cleveland, O.

Perpetual Motion

Mr. Kirlin's perpetual-motion machine, described in a recent issue, calls to mind the accompanying diagram of a scheme which is submitted to the readers of POWER as being more plausible and having less gear than Mr. Kirlin's device. The basic idea is the same, viz., the get-

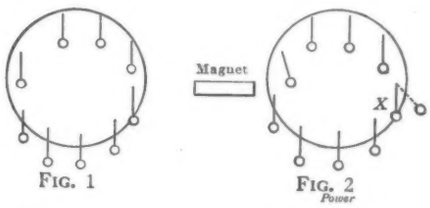


DIAGRAM OF MAGNETIC PERPETUAL-MOTION MACHINE

ting of something for nothing, which does not occur in New York.

Fig. 1 illustrates a disk mounted on an arbor and having on its periphery a number of studs. Suspended from each stud is a short bar magnet made of round steel. The axes of these suspended magnets are held parallel to the axis of the disk-supporting spindle.

Fig. 2 is the same disk save that a bar magnet has been so placed that the suspended magnets are repelled as they pass in front of the stationary magnet.

Obviously the system is unbalanced and rotation seemingly would take place. Another magnet could be similarly placed at *X* so as to repel the suspended magnets away from the center.

Naturally the speed of such a device must be very low to neutralize the effect of centrifugal force. There would be some retarding effect due to eddy currents set up in the supporting disk. The appliances could be run (?) in a vacuum and thus the resistance of the air would be eliminated.

There is a fallacy somewhere but it is not visible to me.

WESLEY MCARDELL.

Brooklyn, N. Y.

Engineers' Wages

As to the suggestion of Waldo Weaver in POWER of May 17, that if engineers would furnish POWER with information concerning their wages, hours of work and pay for extra time, etc., it would add to the means of getting increases in wages, I think it is a good one.

I am in charge of a 760-kilowatt station which contains six dynamos, five engines, three pumps and three water-tube boilers. We are preparing to install a 500-kilowatt low-pressure turbine and other apparatus.

Having had a little experience with boilers and engines, and desiring more, I went into this plant as fireman to learn engineering and by keeping my eyes and ears open, and making it my business to know how and why things about the plant were done; by studying catalogs, instructions, etc., on the apparatus in the plant; by assisting to make repairs and by watching and remembering how they were made, I gradually advanced to take charge of the plant. My wages increased from time to time, from $50 to $90 per month.

On several occasions, knowing that it would be quite a proposition to get the desired increase and confident that the position was worth more, I looked around for a job that offered more than I was getting. Then having this place open, I would put it up to the "Old Man" and I always got my raise. The "Old Man" here knows what he is paying out wages for.

It is hard to show some men that their engineer is worth more money; it is hard for some engineers to approach the "Old Man" for more money, and it is hard for some men to make themselves worth more money. I knew of an engineer in a small plant who wanted a raise but would not ask for it and quit, thinking that the "Old Man" would offer him more to come back. This is a poor way to get an increase in wages.

I average 10 hours per day and get no pay for extra time. I do not lose any pay when I am off for a day or so, or am sick.

It pays one to do his work as thoroughly as if he were doing it for himself; gain the confidence of the "Old Man," be truthful and faithful.

The responsibilities of operating engineers have grown much faster than their salaries. The power-plant engineer must be continually studying to keep up

with his profession. I do not know of any other class of skilled mechanics that must study, plan, think, work long hours and carry responsibilities and yet receive such small salaries as the stationary engineers.

C. E. NIGH.

Morgantown, W. Va.

The Designer Can Save Repairs

I read with interest the article in the June 7 number entitled "The Designer Can Save Repairs." It interested me particularly because I had met the same trouble in the erection of a small upright engine. The parts came disassembled and I put the flywheel and disk on the shaft while on the floor. After considerable twisting and turning I managed to slip the disk through the frame.

The designer cannot be expected to foretell, however, all the things that might result from any particular design of apparatus. We have, for example, a number of 10-inch gate valves on the

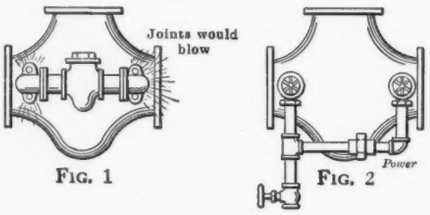


FIG. 1 FIG. 2

ORIGINAL AND IMPROVED DESIGN OF BYPASS

main steam header. Attached to each valve is a bypass. The bypass is in the form of a gooseneck around the body of the valve as shown in Fig. 1. The bend was so short and ridged that we were continually bothered with joints blowing out. To remedy things we removed the old bypass entirely and tapped out the holes for a 1-inch extra-heavy pipe and connected up as shown in Fig. 2. This arrangement gave free expansion and we haven't been bothered since.

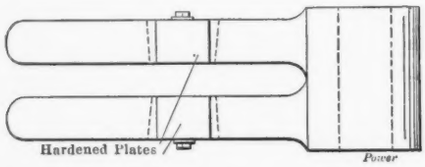


FIG. 3. CAM WITH PLATES TO RECEIVE WEAR

In another case the designer failed to foretell the possible wearing down of a cam that opens the exhaust valves, which are of the single-beat poppet type, on one of the low-pressure cylinders. This necessitated the dismantling of the whole valve casing to remove the defective cam. We now have the cams planed out and a hardened plate dovetailed in as shown in Fig. 3.

H. R. BLESSING.

Philadelphia, Penn.

Loose Crank Pin

In the June 7 issue, Mr. Forgard asks for information and advice about a loose crank pin on his engine. It is hard to assign a cause for a crank pin becoming loose, as there are so many causes. Bad valve setting or working under a high steam pressure will often loosen a pin. A continual sharp jar will sometimes start a pin. When a pin gets loose, bradding or driving pins or screws have very little merit as a remedy.

The only satisfactory method of dealing with a loose crank is to remove the pin and put in a new one.

It may be necessary to bore the pin seat so that it will receive the new pin. This can be done in a simple manner right in the engine room by the use of a hand boring bar, which is shown in Fig. 1. The bar *O* is supported by two bearings *X*, which are blocked away from the disk and clamped in the manner shown. The cutter *P* should be large enough to clean up the old bore. The bar is fed by the screw *E* and nut *D*, which must be supported from some part of the engine frame or crank disk. The bar may be turned by a hand crank applied to the square head at *C*.

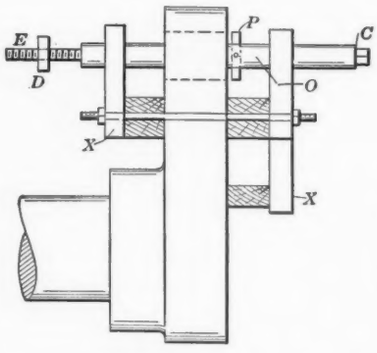


FIG. 1. ARRANGEMENT FOR BORING

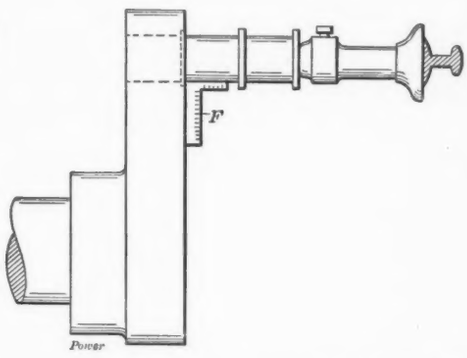


FIG. 2. JACK IN POSITION TO PRESS IN THE PIN

When the seat has been bored out the new pin can be put in place by heating the disk and inserting the pin. Another way in which the pin can be put in is by pressing it in with a hydraulic jack, as shown in Fig. 2. A yoke made of railroad iron or other strong material must be erected to support the jack. A small square *F* should be used to set the pin true before it is pressed.

A pin with a collar on it, as shown, will make a better job. The seat may be counterbored to receive the collar.

Sheffield. Ala. C. R. MCGAHEY.

Boiler Explosions

The letters recently published on this subject have been very interesting to me, perhaps more than ordinarily because I have had experience with a return-tubular boiler which was operated without any exact knowledge of where the water level was.

At the time I was only a boy and was employed to fire that boiler. I had to get steam up in the morning and keep it up as long as the inspirator would supply enough water to keep water in the boiler.

There was no license law in force at that time, and the owner of the shop was boss. I had told him that every morning the water was low and he said to "fire up easy like" until I had steam enough to start the inspirator, then just hold the steam steady until water showed in the glass and then "put the fire to her."

As I have stated, I was a boy at the time, and I felt that I must do as the boss told me.

I had an idea that this practice was not good, yet nothing unusual ever happened. When the inspirator could not keep the water in the glass, we either gave that leaky old boiler a bran mash or shut off the engine until the inspirator got a "head-start" again.

Readers may think that this was too bad a condition to last, but I know that this method of operation continued for months.

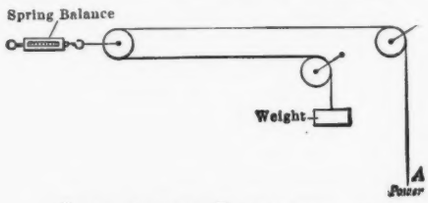
One of the shop hands told me before I came to fire the boiler, that the shop had been shut down for a few days and a son of the boss had emptied the boiler, and cleaned it out but had not filled it up again. A man from the shop attempted to get up steam and a fire was under the boiler long enough to generate plenty of steam but the gage showed that there was none. Investigation showed that the boiler was dry and red hot. When they looked around to find the leak they found that the blowoff valve was wide open.

This boiler has not exploded yet and was still being used a few years ago, carrying 85 pounds gage pressure.

Cleveland, O. H. W. BENTON.

Troubles with the Tension Carriage

The letter by T. C. Thompson bearing the above title in the July 5 number is accompanied by a sketch which makes the reason for the trouble clear. With the rope rove as shown, Mr. Thompson is right in his opinion that the tension sheave should be located between the idler sheave and the line-shaft sheave. However, it is possible by a change in



EXPERIMENTAL DEMONSTRATION

the method of reeving the drive practically to cure the trouble. As shown, the rope runs from the top of the flywheel to the idler sheave, thence to the tension sheave and then to the top of the line-shaft sheave, when the drive is in operation. The relative location of the sheaves, however, seems to indicate that the drive was designed to operate with the rope running from the bottom of the line-shaft sheave to the tension sheave, thence to the idler sheave and then to the bottom of the flywheel.

There is a reason for this last manner of reeving the drive and as a substitute for the mathematical demonstration the experimental demonstration shown in the accompanying sketch is suggested. Note the difference in the reading of the spring balance when raising the weight and when lowering it by power applied to the fall *A*.

A. D. WILLIAMS.

Cleveland, O.

Faulty Reducing Motions

In the issue for June 28, A. C. Waldron in writing of faulty reducing motions shows in Fig. 1 what he calls improper and proper ways of attaching the drum cord to the reducing lever.

A description of the mental process by which he arrives at the conclusion that either of the methods shown can be called proper would make highly interesting reading, for if the diagrams shown in Fig. 2 were got from an engine with one of the reducing levers it would be impossible to get Fig. 3 by using the other.

While the sector if correctly made and attached would lead the cord to the drum in a direction more nearly right than if led from the screw eye as shown on the other lever the sector introduces other errors that are greater than would happen if the cord led from a pin in the center line of the lever and at right angles to it with the crosshead at midstroke.

The diagrams shown are clearly fakes and the conclusions he draws are erroneous, and though no engineer experienced in accurate indicator work will be deceived, some young member of the craft may be led into error by taking the article seriously.

H. M. DARLINGTON.

Midland, O.

Operation of Stop Valves and Cocks

Mr. Row, in the issue of June 28, states that because a blowoff cock is close to the boiler, the weight of water in motion will be small and the water-hammer produced by the sudden closing of the cock is negligible. This would be correct were not the water in the boiler under pressure.

When the blowoff cock of a boiler carrying steam at 150 pounds pressure is opened, the velocity of efflux of the water is approximately 156 feet per second. Even though the weight of water in motion is small, the hammer produced by the sudden stoppage of a flow at this velocity is large and liable to cause accident.

P. LANCASTER.

Monterey, Mexico.

The caption on page 1178 in the June 28 number, "Never Open or Close a Stop Valve Suddenly," gave me quite a start. But the added admonition which the article contained, "Always close a blowoff valve quickly" is enough to make an engineer's hair stand on end.

We had two boilers, each 6 feet in diameter, one 18 feet, the other, 16 feet long. These boilers were set between two partition walls with just 16 inches between. A ladder and the buck stays almost filled this space through which the fireman or engineer must pass to reach the blowoff cocks at the rear where there was another brick wall just 3 feet from the boiler settings. One night I was in a hurry to blow down the boilers, they were very dirty and on this account I did not trust this duty to the fireman. Rushing back of the boilers I opened the blowoff cock on one and closed it with moderate speed; then I opened the blowoff cock on the other, and in my haste to get away, I swung the wrench around and closed it in one swift sweep. Instantly there was a bang inside the combustion chamber. The back connection door came open at my feet nearly blinding me with hot dust. Scalding steam and water got thick around my feet. I was half blinded and bruised my head and shoulders in trying to get out of the narrow passageway.

The boiler carried 105 pounds pressure and the blowoff was made of 2½-inch extra-heavy pipe and an extra-heavy ell. The side had been blown right out of the ell by the sudden jolt caused by closing the blowoff cock so quickly.

I missed my train that night but I learned a lesson which I shall never forget.

In another plant we supplied steam to run an elevator pump in an office building about 250 feet from the boilers. Our steam line was connected to the heating system in this building near the pump by a 4-inch Y. I usually opened the stop valve at the boilers myself. A new fireman who held a second-class engineer's license asked permission to open the valves. Thinking that I could trust him, I consented after showing him the way in which I usually operated them. They were 6-inch gate valves. I would open a valve just enough to hear the steam hiss through; in about 10 minutes, I would open it a little more and so on until after about one hour the valve was half open. It could be opened the other half without waiting.

Somehow I suspected this man of opening the valves before the pipe could be warmed up, the bends expanded and the pockets freed from the water of condensation and I again cautioned him to open the valve slowly and allow plenty of time for the pipes to warm up.

One morning a gasket blew out of a 4-inch line in the building near the pump. Some time later, as the woman who cared for the offices was about to descend the stairs, a 4-inch Y just over the foot of the stairs entering the basement let go. Had she been 10 seconds earlier she could not have escaped suffocation. The fireman had opened the valve quite suddenly. The rush of water ahead of that 90 pounds of steam, together with the vacuum formed by the partial condensation, increased the velocity, and the quantity of water which did not drain out was driven hard against the two valves back of the Y. The Y, being the weakest, split from end to end. It is possible that the valves might have been broken had the volume of water not been divided and reduced.

R. A. CULTRA.

Boston, Mass.

Depreciation

I was much interested in the editorial in POWER for July 5 on depreciation. This is a subject to which I have given a great deal of study in recent years, and concerning which I have collected a vast amount of data.

Depreciation is of importance: first, in appraising the present value of plants; second, in ascertaining the actual or total cost of the product; and third, in fixing proper rates for service, as in public utilities, such as water works, electric-light plants, etc.

Depreciation in general is of three kinds: that due to physical decay; that

due to obsolescence, and that due to inadequacy. All of these must be considered in any given case.

I do not, however, agree with the statement that depreciation is more rapid in the earlier years of a plant's life than later. This may be true if merely the market value is considered, but that is not the proper criterion. The unit must be considered with reference to the purpose for which it was installed, and for which it is being used. As a matter of fact, in most cases not only is there no depreciation in the earlier years, but the value may actually increase. This is particularly true of the real estate occupied by the plant. It is often true also of apparatus, due to its advanced cost in the market. More particularly, however, is it due to the fact that the unit has demonstrated its fitness for the service, and is no longer experimental. The owner of a unit which has met all expectations, and is doing entirely satisfactory work, would not trade it for an entirely new unit, within, say, the first five years of its life. Furthermore, the actual wear and tear is usually at a minimum during the earliest years. This fact is recognized by some able engineers, who recommend that there be no depreciation charge for the first years of public-utility plants, such as water works, etc.

There are many different methods of handling the depreciation account. I understand that it is common in machine shops to allow each year 10 per cent. of the preceding year's inventory value. This is objectionable because it makes the depreciation charge largest during the earlier years when, as shown above, it is actually least. Furthermore, it is during these years that many enterprises—such as water works and electric-light plants, etc., which are building up their business—can least afford a heavy depreciation charge. The most serious objection to this plan, however, is that it never entirely wipes out the account.

The plan of charging a fixed percentage every year throughout a definite period is better, but it is also open to the objection that the charge is not consistent with the actual depreciation, and is, furthermore, larger than it need be.

The plan preferred by the best authorities seems to be what is known as the sinking-fund plan. A life period is assumed for the plant, or for each of its units, and an amount is set aside each year, which amount, compounded at a reasonable rate of interest, will, at the end of the period assumed, have grown to a sum sufficient to replace the machine. Under this plan a unit with an assumed life of 20 years would not require 5 per cent. allowance each year, as its value would be repaid in the period named by an annual assignment of 3½ per cent., compounded annually at 3½ per cent. interest. Sometimes this fund is not begun until several years after the starting of the plant, in which event the annual charge must be somewhat larger on account of the remaining life period being shorter.

It is interesting also to note another way of computing depreciation, namely as a percentage of gross earnings instead of plant value. While this plan is common among large electric-light and railway properties, it does not seem to the writer to be entirely logical. It is defended, however, on the ground that the wear and tear on the plant is to a considerable extent proportional to the gross income.

WILLIAM H. BRYAN.

St. Louis, Mo.

The Selection of an Engine

I am glad to have A. V. Clarke take up, in the issue of July 12, the discussion of "The Selection of an Engine" by criticizing my statement in regard to condensation. He must have misunderstood my meaning from the answer he gives, "In the first place." My whole analysis was based on the assumption of approximately an equal cutoff for each engine, and my statement in regard to cylinder condensation, of course, rested on the same assumption. His criticism on that point is, therefore, irrelevant.

He then compares two engines, one a 20x30-inch running at 100 revolutions per minute, the other a 16x30-inch running at 160 revolutions per minute, each developing approximately 200 horsepower; and he states that the larger engine at the lower speed will be the more economical because it has less surface exposed to the steam and therefore less cylinder condensation. I do not agree with Mr. Clarke by any means and my own experience bears me out in what I here set forth.

Assume that both engines are cutting off at one-quarter stroke. The surface exposed to the steam up to this point in the 20x30-inch or low-speed engine is, then,

$$330 \times 2 = 660 \text{ square inches (cylinder head and piston)}$$
$$\pi \times 20.5 \times 7.5 = 478 \text{ square inches (cylinder barrel)}$$
$$1138 \text{ square inches, total.}$$

For the 16x30-inch or high-speed engine it is,

$$207 \times 2 = 414 \text{ square inches (cylinder head and piston)}$$
$$\pi \times 16.25 \times 7.5 = 383 \text{ square inches (cylinder barrel)}$$
$$797 \text{ square inches, total.}$$

The low-speed engine has,

$$\frac{1138 - 797}{797} = 0.429 = 42.9$$

per cent. more surface exposed than the high-speed engine. The speed of the two engines will not enter into this calculation, because although the small engine runs at 60 per cent. greater speed than the large engine and therefore exposes the surface a greater number of times; the steam in the large engine is exposed to the surface in its cylinder 60 per cent. longer per revolution than in the small engine.

In making my calculations I am inclined to disregard the polished surface of the cylinder barrel, and consider more particularly the surface of the cylinder heads and pistons which are not as a rule highly polished and which are far more carefully to be considered in connection with their effect on cylinder condensation because of their much greater "regenerative capacity" as I call it. In other words, these rougher surfaces have a much greater capacity for absorbing and radiating heat than have the polished walls of the cylinder barrel. Taking the surface of the cylinder heads and pistons as the more important basis of comparison we find that the low-speed engine has

$$\frac{660 - 414}{414} = 59.5$$

per cent. more exposed surface than the high-speed engine, and the latter is far more economical. My experience, both in automatic-engine work with noted Eastern builders and with the "Higher Speed" Corliss engines of the Wisconsin Engine Company, bears me out in this.

In addition to advantage in having less surface exposed to the range of temperature, the small, high-speed engine has a great advantage in respect to clearance, which is all important on the score of economy. Reduced clearance again means less surface in the ports and passages which will be exposed to the range of temperature. This surface being cored, and therefore comparatively rough, has a still greater "regenerative capacity" and it is very important for economy to reduce it to the very smallest amount.

To go back again to the original article of Mr. Miller, the only real point he made against the 16x36-inch engine running at 150 revolutions per minute, was the piston speed, and he rests seemingly secure on this as he gives no reason for his stand. But outside of the fact that for years Corliss engines have been running at piston speeds of 900 to 1000 feet per minute, it would seem that in these days of the flying machine, wireless telegraph, ocean greyhounds, marvelous machine-tool development and foundry practice, that reputable builders could be taken at their words when they offer to stake their reputations and cash in offering and building such engines. The wear and tear at these speeds in properly designed engines, I know from eight years' experience, is practically *nil* and the real precaution to be taken by the purchaser is to be sure that the ports and passages in the cylinder have ample area to give the engine the advantage of the full range of pressure and enable it to show a diagram mean effective pressure very close to the theoretical.

CORNELIUS T. MYERS.

Racine, Wis.

Backing Trials of Scout Cruisers

These tests, in which the "Chester", "Salem" and "Birmingham" participated, showed that the reciprocating engine provides better backing power than the turbine, does not require the installation of additional units and causes no drop in boiler pressure.

In the beginning of our experience with turbines attention was naturally centered on their engineering characteristics, such as steam consumption, and details of construction and operation. With the satisfactory development of these elements, we have been able to devote more attention to the tactical features involved, as affecting the ease of handling turbine-engined vessels.

With reciprocating engines a backing power about equal to the ahead power is afforded without any increase in weight except that of the backing eccentrics, rods and links. With turbines, however, backing power requires additional turbines with a considerable increase in weight.

It is necessary therefore to restrict the backing power of turbines to that actually required by tactical considerations. The practice has been to provide a backing power estimated at about 50 per cent. of the ahead power. It has been found, however, in practice that this backing power is rather less than 40 per cent. of the ahead power.

Trials have recently been held with the three scout cruisers, "Chester," "Salem" and "Birmingham," to determine the sufficiency of the backing power provided respectively by Parsons and by Curtis turbines, and as compared with that obtained by reciprocating engines. The criterion has been taken as the distance head reached by the vessel during the interval required to bring her dead in the water from a given speed ahead. A general description of these vessels has been given in a preceding issue.

The trials were conducted with great care and thoroughness, the conditions of displacement, sea, speed, and number of boilers in use, were practically identical for all, and the results may be taken as an authoritative indication of the relative backing powers of the three types of prime mover as now installed.

The speeds selected for the trials were 10, 16, 22 and 24 knots. Three runs were made by each vessel at each of the two lower speeds, two runs at 22 knots, and one run at the high speed. At each speed only the boilers required for a sustained run at this speed were used.

There was no bottling up of steam preparatory to backing, and no speeding up of blowers during the backing interval. It was required that the boiler pressure be not reduced to such an extent as to cause priming.

The results are shown in the following table:

Time to stop from instant of signal for reversal.			Distance head reached in ship lengths.		
C.	S.	B.	C.	S.	B.
M. S.	M. S.	M. S.			
1:52.7	1:20.4	1:10.3	2.2	1.8	1.5
2:06	1:27.3	1:21.2	4.3	3.0	2.6
2:08.5	1:37	1:03	5.4	4.2	3.0
2:51	1:40.5	1:09	6.5	4.7	3.2

It will be noted that at all speeds the reciprocating engine provides better backing power than the Curtis turbine, and that the latter is superior to the Parsons turbine.

The average time required for reversing, and the fall in boiler pressure during the backing interval were as follows:

	Average Time to Reverse in Seconds.	Average Drop in Boiler Pressure, Pounds.
Parsons turbines.....	8.2	82.4
Curtis turbines.....	39.2	75.8
Reciprocating engines...	5.1	none

In the case of the "Birmingham," the average boiler pressure at the end of the backing interval was 1.5 pounds greater than at the beginning of the interval.

Notes on Marine Condensing Plants

By H. E. King

Current practice in the condensing equipment of naval and merchant ships, including rules to determine the amount of cooling water required and the size of the air pump.

To run a marine engine condensing means a gain of at least 15 per cent. over noncondensing, and if a surface condenser be used instead of a jet it will mean a longer life for the boilers and there will be a saving in fuel. The general arrangement of the condensing plant is fairly well stereotyped, the chief variation being in detail. A usual arrangement of condenser and air pump for merchant service is shown in Fig. 1; the condenser is formed in the back columns of the main engine, and the air pump is worked by a link from the engine crosshead *B*. The air-pump rod is extended through the guide *C* and works on the crosshead *D*. Frequently a reciprocating circulating pump is placed beside the air pump and in many cases these are flanked by the bilge and feed pumps, all worked from crosshead *D*. The arrangement is compact and cheap, but one part cannot be repaired without stopping the whole; it is, therefore, better suited to cargo boats than to warships or fast passenger ships where immunity from breakdown is vital.

On naval and fast passenger ships it is usual to arrange the plant similar to that in Fig. 2. The condenser is shown at *O* connected to the twin air pump which discharges past the air separator *B* and through the grease filter *J* to the feed tank *F*. Any water carried up by the air falls into the funnel at *A*, and passes to the feed tank. The plant shown is for a twin-screw installation and a cross connection *G* regulated by valves *D D* connects the air pumps in each engine room. The circulating-water inlet is at *I* and the discharge at *K*, the centrifugal circulating pump being driven by a small steam engine shown at *P*.

Four-cylinder triple-expansion engines are usual in large warships, a low-pressure cylinder being placed at either end, in which case each has its own condenser; the plant shown in Fig. 2, with the exception of the air pump, being duplicated.

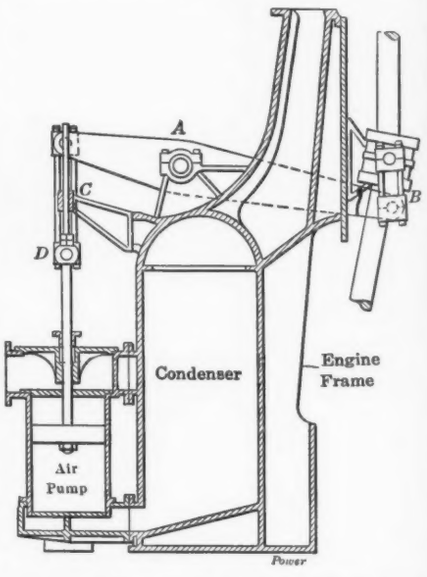


FIG. 1. CONDENSING PLANT WORKED FROM MAIN ENGINES

The Condenser

Great care must be exercised in proportioning the condenser, for which the total steam to be condensed, the initial temperature of the circulating water and the required vacuum must be known. On a few naval and merchant vessels a small auxiliary condenser together with air and circulating pumps is provided for the exhausts from the auxiliaries, but in this case, at full power, the "closed exhaust" system is used; that is, the auxiliary exhausts are passed into the low-pressure receiver, thereby throwing the additional load on the main condenser. With the cramped engine rooms of most modern warships, the auxiliary condenser has been crowded out and the main plant is used for all purposes.

The quantity of condensing water required per hour per pound of steam may be obtained from the following:

$$W = \frac{1134 - 7T_2}{T_2 - (T_1 + 20)} \times (1.25 \text{ to } 1.50)$$

where,

W = Pounds of condensing water per pound of steam per hour,

T_2 = Temperature of the steam at the required vacuum,

T_1 = Initial temperature of cooling water in degrees Fahrenheit.

The above quantities are based on a cooling surface of 1 square foot per 8.5 to 10 pounds of steam per hour. Naval practice is to keep the cooling surface small with a large amount of circulating water. The condenser may be of any shape to fit the available space, but the usual form is cylindrical.

Air Pumps

Air pumps for marine purposes are usually of the head-, foot- and bucket-valve type, although the Edwards pump is much used. When driven from the main-engine crosshead, the length of the large lever, Fig. 1, should be adjusted so that the bucket speed does not exceed 300 to 450 feet per minute. The effective capacity of the pump may be found by either of the following rules:

1. Volume swept through by the pump piston = one-tenth to one-sixteenth of the volume swept through by the low-pressure piston of the main engine.

2. Volume handled by the pump = 7 to 8 cubic feet per pound of steam condensed.

It is advisable to fit an air separator on the discharge, the working of which has already been explained in connection with Fig. 2. Air pumps should not work against much head, and when discharging into a hotwell, if the feed tank is much above this level, a special "hotwell pump" should be fitted.

Circulating Pumps

As previously pointed out, centrifugal pumps are most suitable for the special needs of warships and fast passenger vessels; they are usually driven by small steam engines, and in this connection some special requirements should be noted. Referring to Fig. 2, it will be seen that the pump has a bilge suction at L and in case of accident the water can be pumped out through valve K. To prevent the condenser tubes becoming clogged, the inlet and discharge openings are bypassed by a valve inside the condenser. Obviously the work done in clearing the bilges is considerable; therefore, the pump engine must be designed for this duty. When there are two sets of condensing pumps, it is usual to arrange a cross connection between them.

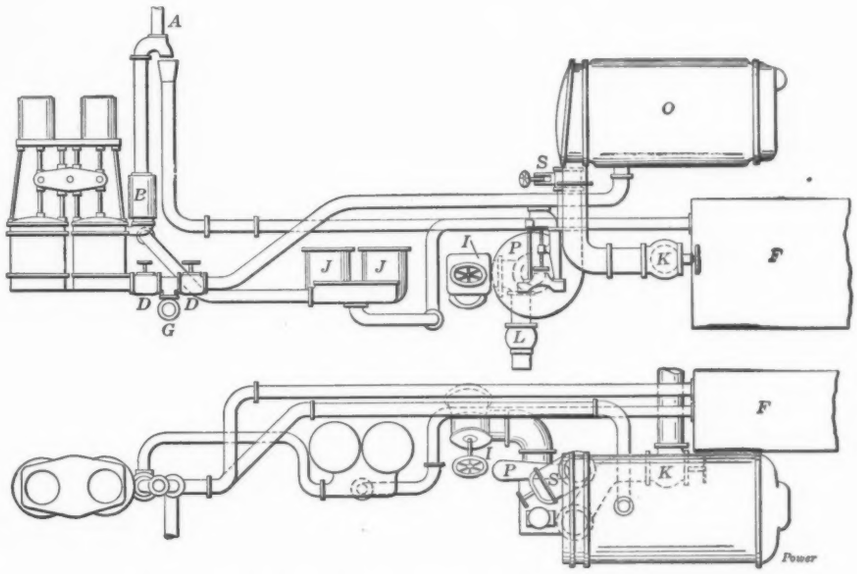


Fig. 2. Condensing Plant Separate from Main Engines

American Peat Society Convention

The fourth annual meeting of the American Peat Society was held at Ottawa, Ont., July 25, 26 and 27. Representatives of the peat industries in various parts of Canada and the United States were present. Many interesting papers dealing with the manufacture of fuel and fertilizer from peat were contributed.

On the afternoon of July 25 the society visited the peat bog owned and operated by the Canadian government. The bog is located at Alfred, which is about 40 miles east of Ottawa. About 30 tons of air-dried peat are manufactured per day.

On the afternoon of July 26 the government fuel-testing plant in Ottawa was visited. The plant consists of a double-zone peat gas producer, wet-coke scrubber, tar filter and dry scrubber and a four-stroke cycle single-acting Koerting gas engine to which is connected a 50-kilowatt Westinghouse direct-current generator. Peat fuel manufactured at the government bog is used in the producer. Both the fuel-manufacturing plant at Alfred and the testing station at Ottawa will be fully described in a later issue.

At the banquet held on the evening of the second day among those who responded to the toasts were: Hon. Sidney Fisher, Minister of Agriculture in the Canadian Cabinet; Col. J. G. Foster, United States consul; Prof. Charles A. Davis, peat expert, United States Bureau of Mines; Robert Ranson, St. Augustine, Fla., and Dr. J. McWilliam, London, Ont.

The officers for the ensuing year are: President, Dr. Eugene Haanel, Director of Mines, Canada; vice-presidents, John N. Hoff, New York City, Eastern States; Carl Kleinstueck, Kalamazoo, Mich., Great Lakes and Mississippi valley; Robert Ranson, St. Augustine, Fla., Southern States; C. V. Imeson, Los Angeles, Cal., Pacific States; Dr. J. McWilliam, London, Ont., Canada; Dr. Charles T. McKenna, New York City, New York section; O. E. Moulton, Dover, N. H., New England section, and Max Folty, St. Paul Minn., Minnesota section; secretary and treasurer, Julius Bordollo, Kingsbridge, New York City. The offices were held by the same men last year, all of whom were reëlected by unanimous vote.

Kalamazoo, Mich., was selected as the place at which to hold the next annual meeting. The date of the meeting will be determined later.

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Contents

PAGE

Dimensions of Steam Turbines..... 1412
Data on Central Station Operation..... 1415
Flue Gas Analysis and Calculations.... 1416
Coal Handling, Wood Worsted Mills.... 1418
Centrifugal Pump Characteristics..... 1421
Application of Thermal Storage..... 1423
Mechanical Refrigeration..... 1424
Storage Batteries in Isolated Plants.... 1426
A 135,000-volt Transmission System for Michigan 1429
Rotary Converter Commutators and Rings, Switchboard Operators' Salaries 1429
Elementary Lectures on the Gas Producer 1430
Gas Engine Reliability and Economy... 1431
A Cure for Porous Gas Engine Cylinders 1431
Practical Letters:
Pumping Layout for Criticism.... Water Hammer in the Feed Line ....Why the Boiler Would not Steam....Dismissal without Cause ....What Causes the Vibration? .... Pump Problem .... Finding Areas of Irregular Figures....Operating Mechanical Tube Cleaners ....Trouble with an Oiling System ....Rumbling in Boiler....Graphite as a Lubricant....Packing a Feed Pump.....1433-1435
Discussion Letters:
Steam Tables .... Central Station vs. Isolated Plant....Accident to Blowoff Tank....Perpetual Motion ....Engineers' Wages....The Designer Can Save Repairs....Loose Crank Pin .... Boiler Explosions ....Trouble with the Tension Carriage....Faulty Reducing Motions ....Operation of Stop Valves and Cocks....Depreciation .... The Selection of an Engine.....1436-1440
Backing Trials of Scout Cruisers..... 1441
Notes on Marine Condensing Plants.... 1441
American Peat Society Convention..... 1442
Editorials 1443-1444

Power and The Engineer

Editorial

The Purchase of Coal

There are various ways of buying coal in vogue at the present time; one extreme is buying it without any knowledge of its weight or quality and trusting to providence and to the dealer for value received. The other extreme is to buy the fuel on a B.t.u. basis and subject it to a careful analysis and accurate weighing.

For many years the farmers in this country have been protected in the buying of fertilizers by State inspection so that they have a positive guarantee of the contents and value of each bag. The ordinary coal user has no such protection although he stands as much in need of it as the other. Coal dealers are probably neither more nor less honest than other people but there are many slips between the loading of the coal at the mine and the delivery on the premises of the ultimate purchaser. One rather amusing instance of such a slip occurred not many years ago in one of our large cities where coal supplied by a local dealer to an educational institution was found to be short in weight on each wagon load. The employment of detectives who traced the car from the yards to the college revealed a peculiar set of conditions. The coal was carefully weighed at the yards, but on its way to the place of delivery was hauled through a narrow street and a gentleman with a pushcart was seen to come from a neighboring alley, fill up his cart from the load on the wagon and return whence he came. An investigation showed that the coal thus pilfered was sold in a retail store in a poorer quarter by a company in which the drivers were interested, each driver receiving a certain percentage of the profits of the business.

In the purchase of slack coal, the prevailing rains have much to do with the actual amount of fuel that is received by the buyer. To weigh and test coal which is purchased in large quantities is no more reflection on the honesty of the coal dealer than an examination of a check at the bank reveals distrust of the honesty of the one presenting it. It is merely a business precaution which should be taken by anyone purchasing coal in large quantities.

Buying coal on a B.t.u. basis involves the employment of an expert chemist who will make calorimeter determinations of the heat value and ultimate analyses of the fuel itself. Such a chemist should not be in the employ of either seller or buyer but should be a disinterested expert. The expense and trouble attendant on proceedings of this kind will probably prevent their general adoption except in the case of companies buying coal in large quantities. A compromise frequently adopted is the use of a proximate analysis which can be handled by any intelligent engineer and which gives with sufficient accuracy for commercial purposes, the amount of moisture, the volatile matter, the fixed carbon and the ash. The same engineer could probably manipulate also a bomb calorimeter with sufficient accuracy for commercial determinations of the B.t.u. Too much stress, however, cannot be laid on the importance of getting fair samples in such tests. The methods of sampling coal given in the standard boiler code should be carefully followed.

A method simpler than either of the above and perhaps just as efficacious in many instances, consists in weighing the total ash and determining the scale of prices according to the percentage of ash found. If all of the coal used in a given plant is obtained from the same district, there will be little variation in the amount of volatile matter and carbon present. The variation in efficiency will be due to a greater or less percentage of ash.

Car loads of coal from the same mine frequently show a great difference in this respect owing to the particular part of the vein in which each load was mined. An examination of the report of the fuel-testing plant of the United States Geological Survey at St. Louis shows for the coals of a particular locality, a close correspondence between the percentage of ash and the heat value of the coal. Plotting points on these two quantities as coördinates gives approximately a straight line; that is, the B.t.u. in the coal will be inversely proportional to the percentage of ash. It will then only be necessary for the purchaser to weigh his coal, to make an ordinary moisture determination if he pleases so as to find if the coal is unreasonably wet, and finally to keep a record of the amount of ash from each carload. A sliding scale of prices could be arranged on this basis, a certain price being agreed upon for a sample load containing a certain proportion of ash, and then a certain number of cents per ton being added or subtracted for each 5 or 10 per cent. varia-

ation in the ash content. This method of testing coal involves no skilled labor and no unnecessary work and as long as the coal comes from the same locality, will give an index of its calorific value which will probably be accurate enough for ordinary transactions. It will certainly be a great improvement over the usual method of buying coal without any knowledge or standard of its value.

Thermal Storage

On another page of this issue we print an excerpt from our contemporary, *The Engineer*, upon the subject of "Thermal Storage." Under this particular guise the system, of storing heat during periods of light load to be utilized during the peak load, seems to have been used extensively in England, although we are not aware of it having been used on this side of the Atlantic.

In principle the system is not new; it is analogous to the practice, followed in many well managed plants, of filling the boilers to their limit a few hours before the peak load comes on, with the result that when the peak comes on, the boiler is full of hot water at the boiling temperature ready to be transformed into steam. In this way the capacity of a boiler may be more than doubled for a short time. It is much better practice than that of cutting in additional boilers with the resulting losses.

With the English system, as described, the tests show an hourly evaporation with the thermal storage of nearly double that obtained without it. It should be borne in mind that this refers to the total evaporation per hour, not the economic evaporation, or the evaporation per pound of coal. Furthermore, the duration of the test was only 65 minutes. With a feed-water heater using exhaust steam the heat given up to the feed water represents actual gain, providing the conditions permit the use of such a heater; but with a thermal-storage tank the feed-water temperature is raised at the expense of heat units which would otherwise go into the steam. This amount of heat, however, is undoubtedly less than that which would be required to heat the water to the boiling point if the boiler were fed with comparatively cold water and forced in order to carry the peak load. While the economy is by no means increased in proportion to the increase in evaporation, still we believe there is considerable economy in the particular function which this system performs. Moreover, it permits the use of a smaller boiler than would otherwise be able to do the work, thereby decreasing the first cost of the equipment required to carry a given load, which, of course, still further enhances the economy obtained by reducing the interest charges on the investment in plant equipment.

Safety Valves

The discussion of safety valves may be made to hang on the two questions: What is a safety valve and why is a safety valve? Taking the second one first, a safety valve is put on a steam boiler because the inspector will not pass it without, and this leads to the answer of the first question, that a safety valve is something put on a boiler so that the inspector will pass it.

If this discussion should be thought too trivial even for the hot wave, when we think of steam to avoid it, it may be remembered that in the navy it is not considered good form to allow a safety valve to open or even to leak. And, seriously, a safety valve should never open except when opened to see that it is in working condition. Under some circumstances it would be proper to discharge a fireman who should allow the safety valve to blow. There appears to be only one condition under which it is good engineering practice to allow the safety valve to blow (a little, occasionally) and that is when it is necessary to give ocular proof that there is steam enough and that a failure to make schedule time is not chargeable to the boiler.

A theory of the safety valve assumes that it should be able to discharge all the steam that the boiler can make when forced, without allowing the pressure to run more than a small amount above the working pressure. The basis of this calculation for a safety valve on this theory is the well known Rankine rule for the flow of steam in pounds per second,

$$Weight = A \frac{p}{70}$$

where A is the effective area in square inches and p is the absolute pressure; that is, the gage pressure plus the atmospheric pressure. This rule will give a result 2 or 3 per cent. too large; but that is trivial in the face of the difficulty of estimating the power of the boiler to make steam when forced. The details and difficulties of that estimate and of determining the effective area of discharge may be left to a more convenient season—next January, perhaps.

It appears that some valve makers have found it convenient to insist that one way of working a safety-valve discharge more steam is to open it wider. It is evident that if a safety valve opens twice as wide it will discharge twice as much steam; or what is more to the point a valve having half the area will discharge as much steam. If only the inspector can be induced to see it that way the expense of complying with his demands will be greatly reduced.

But there has never been any trouble about making a safety valve open. Even the old lever safety valve opened promptly at the right pressure and lifted high enough to discharge all the steam the boiler could make. But when it came to closing, the lever valve was altogether too deliberate; it closed slowly, and only after a considerable reduction of the steam pressure, and paid no attention to the matter of good form, and a leaky safety valve is a nuisance anyway.

From this cause came the generation of the pop-safety valve that at once opens wide, and after a very moderate reduction of pressure shuts quite as suddenly. Now the way to stop leakage is to make the seat narrow so that the pressure per square inch is sufficient and though the valve and seat may be made of hard alloy, the combination of narrow surface and sudden closing is apt to approach the limit.

What then if the valve be made to open twice as wide? Well if the inspector does not object and if the fireman never allows the pressure to reach the popping point, nothing happens. Doubtless careful training may enable him to quietly lift the valve to see that it is not stuck.

It is rumored that certain interests have tried out the safety-valve question with the assistance of a competent professional expert. Rumor never quotes technical details, but we may confidently predict that they will report with more exactness and greater authority what is here stated concerning the discharge from safety valves. We hope they will also prove as completely what happens to the seat of the valve when the lift is doubled. Perhaps they will find how to do that too, without eventually leading to the bad form of leaky safety valves.

Lest some reader may conclude that this paper approves the abolition of safety valves, it may be wise to say that there are occasions to be guarded against. The fireman *may* let the pressure rise too high, in which case the blowing of the safety valve should precede his discharge. Something may happen to the engine suddenly and then the steam must be disposed of for a while. But if these occasions were the whole story we could afford to let the valve rise twice as high—and pay for a new seat, if necessary.

In deciding upon the size of the steam piping to be used, keep in mind two very important factors. If the pipe be made too large, not only will the first cost be unnecessarily increased, but the radiation will also be greatly increased; on the other hand, if the pipe be made too small, the friction will be excessive.

If you want anything done, *hire it done*. If you want it done right, *do it yourself*.

The successful engineer is never "stumped" for the lack of proper material or fittings; he can always find something of use in the scrap pile.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it.

Effects of Low Water

What part of tubular boiler would be first affected in case of low water?

W. R. O.

The back head below the rear arch and as many tubes as were uncovered.

Foaming Boiler

What should be done in a case of boiler foaming?

H. A. T.

The flow of steam should be checked by closing the engine stop valve until the water settles, when, by blowing and feeding, enough of the impurities may be removed to permit the safe operation of the boiler.

Heating Surface

How do you find the heating surface of a boiler 14 feet long and a given number of tubes?

E. M. N.

Take the area of the lower half of the shell, the inside area of all the tubes and the area of one head minus twice the area of the ends of the tubes. The sum of these areas will be the heating surface of the boiler, which reduced to square feet and divided by 10 will give the horsepower.

Connecting a Boiler Under Pressure

How would you connect a boiler to a battery of two or more boilers when raising steam?

E. A. D.

When the pressure in the boiler which is to be cut into the line reaches that on the others, the connecting valve should be slowly opened. If the pressures are the same and the pipe is free from water no harm can come from opening the valve quickly, but the possible inaccuracy of the gages and the presence of water on one side or the other of the valve make caution imperative.

Factor of Evaporation

What is meant by the factor of evaporation, and how is it found?

S. O. R.

The factor of evaporation is the number by which the actual evaporation is multiplied to reduce it to the equivalent of the evaporation of water at the temperature of 212 degrees into steam at atmospheric pressure. It is found by subtracting the total heat above 32 degrees in the feed water from the total heat above 32 degrees in the steam at the observed pressure and dividing the remainder by 965.7, the number of heat units required to evaporate one pound of water at the temperature of 212 degrees into steam of the same temperature.

For example, suppose that water entering the boiler at 141 degrees is evaporated into steam at 85 pounds gage pressure. Each pound of water contains 101.9 heat units and each pound of steam 1181.8 heat units; subtracting 101.9 from 1181.8 leaves 1071.9, which divided by 965.7 gives 1.1, which is the number by which the actual evaporation is to be multiplied to reduce it to the equivalent of evaporation from and at 212 degrees.

Steeple and "Fore and Aft" Compound Engines

What is the difference between a steeple compound engine and a fore and aft compound engine?

A. W. F.

Steeple and fore and aft as applied to engines are marine terms meaning tandem and cross compound respectively.

Position of Throttle Valve

How should the steam-throttle valve be placed on an engine?

A. R. M.

It should be so placed that the steam pressure will be against the valve, tending to hold it open.

Object of a Condenser

Why is a condenser placed on the exhaust pipe of an engine?

G. A. O.

For the purpose of condensing the steam on the advancing side of the piston and thus removing the resistance necessary to force the steam out of the cylinder against the pressure of the atmosphere.

Compression

How is the amount of compression in an engine influenced by the speed?

F. R. H.

Not at all. Compression is used in engines for the twofold purpose of filling the clearance with steam and furnishing a cushion to absorb the momentum of the moving parts and bring them to rest with all of the lost motion taken up so that the centers will be passed without shock. In high-speed engines compression is usually carried much higher than in the so called slow- and medium-speed types, but it is not necessary as the piston speed is usually no higher.

Horizontal-tubular Boiler Seams

What is the better seam to use in a tubular boiler, single, double or triple riveted lap or butt and strap joint?

D. O. A.

It depends upon the purpose for which the boiler is to be used. If for low pressure, steam or hot-water heating, the double-riveted lap seam is better, because it is cheaper and is safe because the range of pressure change is not wide enough to produce what is called breathing. For any higher pressure only the butt and double-strap seam should be used.

Brake Horsepower

A prony brake has an arm 6 feet long and with the engine running at 200 revolutions per minute presses on the scale with a weight of 14 pounds. What horsepower is being developed?

L. J. K.

The brake horsepower of the engine is determined by the formula

$$H.P. = \frac{2\pi L N P}{33{,}000}$$

in which

$\pi = 3.1416$,
$N =$ Number of revolutions per minute,
$L =$ Length of lever arm in feet,
$P =$ Weight in pounds acting on scale at a distance L.

In the example given

$2\pi = 6.283$
$L = 6$
$N = 200$
$P = 14$

Substituting

$$\frac{37.69 \times 200 \times 14}{33{,}000} = 3.2$$

the horsepower developed.

The Magneto and the Electric Bell

Why does an ordinary electric bell fail to ring when connected to a telephone magneto?

G. K.

Because the bell will respond only to direct current and the magneto delivers alternating current.

New Power House Equipment

Simmance - Abady Precision CO_2Mbustion Recorder

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news.

A CO_2 recorder made in London, England, by Alexander Wright & Co., Ltd., is now being made in this country by their American branch, the Precision Instrument Company, 49 Larned street, West, Detroit, Mich.

For the benefit of those who are not familiar with this type of apparatus, it might be well to state that this CO_2 recorder is an instrument which automatically, and at three-minute intervals, takes samples of flue gases from one or more boilers, analyzes them for the percentage of carbon dioxide which they contain and records graphically on a chart this percentage of carbon dioxide.

FIG. 1. THE SIMMANCE-ABADY RECORDER

The value of this knowledge to the owner, engineer or fireman, is that he can tell at a glance how complete—or, generally incomplete—the combustion of coal is on his grates, and, with this knowledge, remedy bad conditions of firing, draft, etc. It is, of course, well known, that carbon dioxide is formed by the combination of carbon with air in complete combustion; incomplete combustion produces carbon monoxide, with a loss of two-thirds of the gross available heat. Good combustion should show a certain percentage of carbon dioxide.

The recorder is a simple instrument in a case made of steel. It can, therefore, be stood in any hot or dusty or drafty boiler room, where the firemen can see it working, and is entirely unaffected by outside conditions. It is permanently made, mechanically contrived, and accurate, with little to get out of order and no glass vessels to break.

It works on a boiler or boilers with either forced, induced or natural draft; there is no "lag" in its records, and it is made so as to draw gas continuously without stopping from one year's end to another.

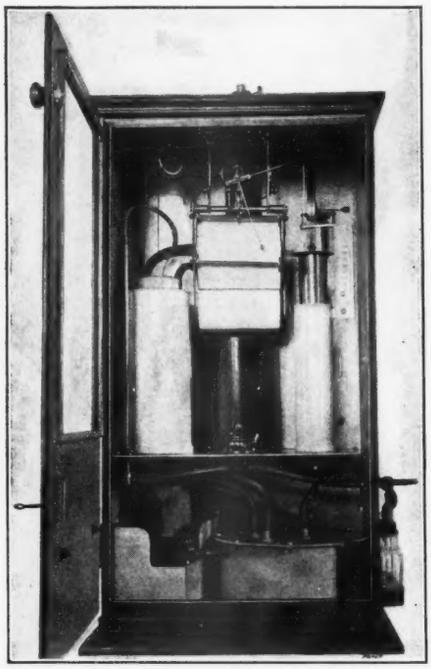


FIG. 2. RECORDER IN CASE WITH DOOR OPEN

It is made either to record the percentage of CO_2 or both the percentage of CO_2 and the flue draft on the same chart, i.e., the conditions producing the percentage. One of the half-dozen types is illustrated in Figs. 1, 2 and 3. Fig. 4 represents a reduced facsimile showing what a record of draft and CO_2 looks like. The chart for May 6 shows 6 per cent. CO_2, that for July 13, 12 per cent. or, according to the chart shown in Fig. 5, a saving of 15 per cent. in fuel.

A small stream of water is the motive power for effecting the whole of the operation which is described in the following:

Water is allowed to drop into the siphon tank *A* from a small reservoir *B* which is fitted with a safety overflow. In the tank *A* there is a float *C* which is attached by means of a chain to the bell *D* of the extractor, and this float rises and allows the bell of the extractor to fall. Assuming that the bell of the extractor is empty, then the float *C* in the tank *A* would be near the top, and when

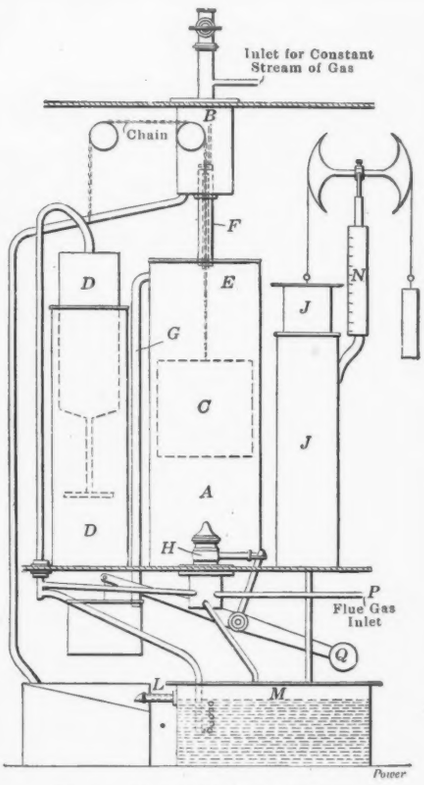


FIG 3. DIAGRAMMATIC SKETCH OF RECORDER

it reaches the top it engages with the drip valve *E* on the water service *F*, quickening the supply for a moment and starting an automatic siphon *G*, and also actuating the pen. The water running from the siphon actuates the balance valve *H* which opens the way from the flue to the extractor, and vents the recorder *J*. Naturally as the water siphons out of the tank *A* the float *C* inside drops, and being heavily weighted, pulls up the bell *D* of the extractor, which is suspended in a vessel filled with water, and owing to the partial vacuum created in the bell a quantity of gas from the flue is drawn into the bell.

The siphoning being finished, the passage from the flue is automatically shut off by the balance valve *H*. The water then runs into the tank *A* lifting the float *C* and allowing the extracter bell *D* to fall. As it does so it will be seen that the contents of the bell *D*, which by the closing of the valve *H* are now uninfluenced by vacuum or conditions in the flue, are first reduced to atmospheric pressure, and then are actually under pressure, and the volume of gas is, therefore, transferred, by bubbling through the separate iron vessel *M* containing a caustic potash solution, to the recorder *J*.

The capacity of the bell *D* is such that the volume from 100 to 0 on the engraved indicating scale *N*, is transferred when the apparatus is being set by air containing practically no CO_2. When the flue gas has been turned on to the apparatus exactly the same quantity (i.e., enough to send the recorder bell up from 100 to 0) is passed from the extractor bell *D*, but on its passage the CO_2 is absorbed by caustic potash in the iron vessel *M* and, owing to such absorption, the recorder bell *J* will not rise to its full hight. It is allowed to automatically rise as far as it will, and a pen (not shown in the section) then marks on the chart its final position.

The percentage of CO_2 in the gas is thus automatically recorded. This bell *J* then vents, sending out the analyzed gas by a separate channel and without mixing or coming in contact with the fresh charge of gas which is brought forward to be dealt with in exactly the same way, the whole of the operation, as well as the continuous drawing forward of the flue gas, taking place automatically by means of the dripping water.

An injector is fixed below to bring along a constant supply of gas. By its means gas is continuously exhausted from the pipes connecting the recorder to the boilers, so that the successive samples analyzed by the instrument are from the boiler flue and not stagnant gas in the connecting pipes. The injector is worked by the small stream of water, the motive power for the recorder, connected at *X* before this enters the top tank of recorder so that no extra water is used for this continuous pump. Two glass bottles, Fig. 1, are fixed in connection with the injector as safeguards. A glance at one shows whether the flue gas pipes are clear of obstructions and the other shows that the stream of water is being maintained.

Attention is called to the simple pen movement, balanced on gilded point bearings, and with adjustments in all directions.

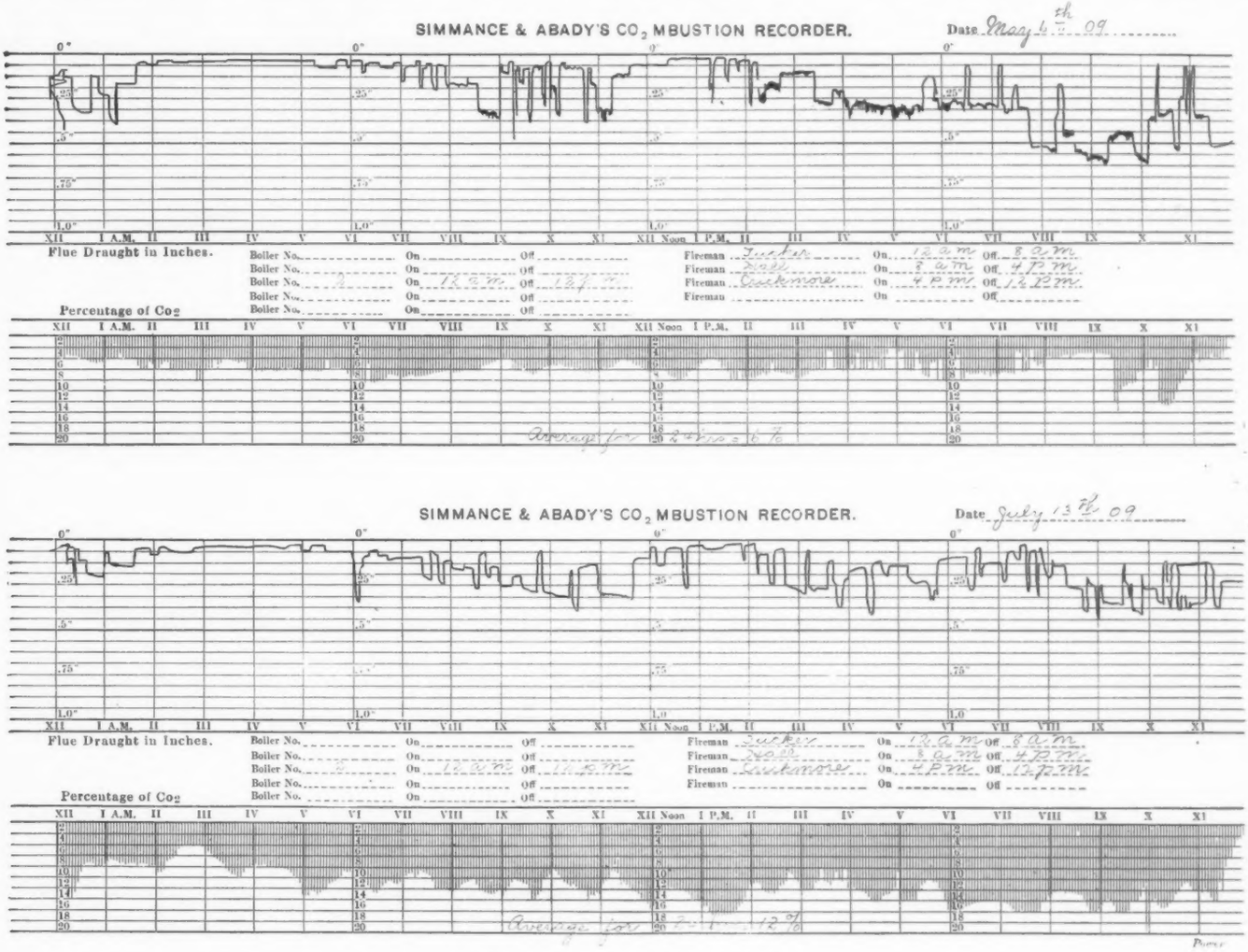

SIMMANCE & ABADY'S CO2 MBUSTION RECORDER.
Date May 4th 09
Flue Draught in Inches.
Percentage of Co2
Fireman Tucker On 12 a m Off 8 a m
Fireman Dale On 8 a m Off 4 P m
Fireman Quickmore On 4 P m Off 12 P m
SIMMANCE & ABADY'S CO2 MBUSTION RECORDER.
Date July 13th 09
Flue Draught in Inches.
Percentage of Co2
Fireman Tucker On 12 a m Off 8 a m
Fireman Dale On 8 a m Off 4 P m
Fireman Quickmore On 4 P m Off 12 P m

FIG. 4. CO_2 AND DRAFT RECORDS

The working of the recorder can be seen all the time, so that although the instrument is in a locked case, yet the stokers can see what effect they are producing and regulate their work accordingly.

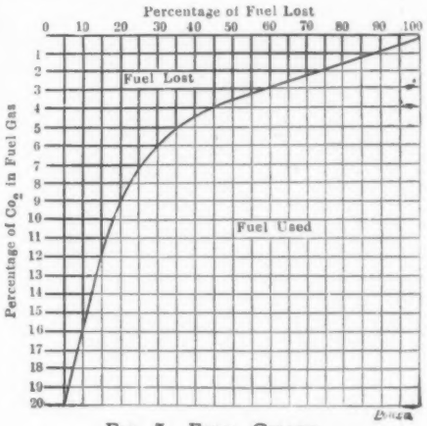

Percentage of Fuel Lost
0 10 20 30 40 50 60 70 80 90 100
Fuel Lost
Fuel Used
Percentage of Co2 in Fuel Gas
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

FIG. 5. FUEL CHART

Its accuracy can be checked at any moment by opening a tap and drawing in air instead of flue gas, when the apparatus will indicate zero, or no percentage of CO_2. There is no troublesome adjustment, no continuous changing of chemical solution. No glycerin, oil, or other similar liquids; but the apparatus is always accurate and unaffected by temperature, evaporation and

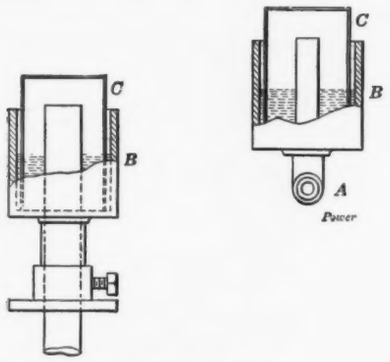


FIG. 6. OIL CUP

all the dusty conditions of a boiler-house, and it contains no perishable parts.

As the recorder continually draws forward hot and dusty gases, the pipes would become stopped up with dust and condensation if some suitable precaution were not taken to prevent it. Therefore, a system of filtering and condensing has been devised which prevents all possibility of pipe stoppage, as shown in Figs. 6 and 7.

A bus pipe or header *A*, Figs. 6 and 7, is run along the range of boilers, and opposite each boiler a tee is placed. On each of these tees is screwed a small iron oil cup *B* and a cap *C* is dropped over the inner tube, shown in Fig. 6, and a little lubricating oil is poured into the cup, thus sealing it. Into each flue is inserted a length of iron pipe (horizontally if a water-tube boiler), and in the end of each of these flue pipes is also screwed an oil cup *B*, and cap *C*, sealed with oil. This furnishes a means of making connection from any boiler to the bus pipe. A filter, Fig. 7, filled with wood wool, glass wool, cotton waste, pumice stone, as most convenient, is placed in the oil

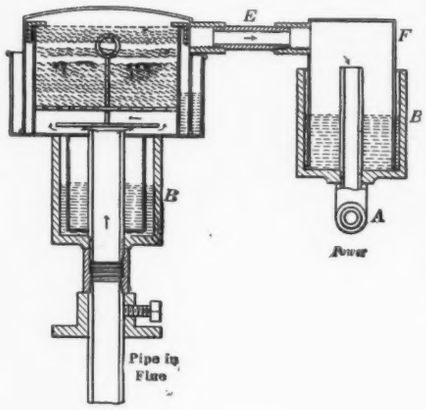


FIG. 7. FILTER

cup *B* of the boiler it is desired to test; after having removed the cap *C*, the channel of the filter is also filled with oil. A piece of muslin is placed over the wood wool or other filtering material in the filter as shown.

Then the filter cover is dropped on and is sealed by the oil in the filter channel. Attached to the cover is a short length of pipe *E*, with elbow and cover *F*, arranged to reach the oil cup *B* opposite on the bus pipe *A*, and it is inserted in this oil cup after the cap is removed. Thus, as Fig. 3 shows, a perfect connection for the flue gas is made which can be removed in a moment to clean the filter, or can be moved on, filter and all, to the next boiler when it is desired to change over. The bus pipe must be run quite parallel to the boiler pipes if this is possible, but if not, a short length of metal-armored hose can be used to connect the filter cover with the bus pipe cover. It will be seen that one set of filter fittings will do for a whole range of boilers, that there is little restriction as to how far off the bus pipe may be from the boilers, that a set of two oil cups and caps is required for each boiler, and that the recorder can be changed from one boiler to another in a minute. There are no cocks or valves to get stopped up or become leaky.

The only attention necessary with this recorder is to put ink in the pen and tear off a chart once a day, wind the clock once a week, renew the solution once a month and put on a fresh roll of charts once each two months.

Canadian Engineers Hold Convention

The twenty-first annual convention of the Canadian Association of Stationary Engineers was held in Berlin, Ontario, July 26, 27 and 28. The business sessions of the convention were held in Victoria hall, and in a large room in the same building, which was specially decorated and fitted up for the purpose, was held the mechanical display under the supervision of the Canadian Exhibitors Association.

At eleven o'clock on Tuesday morning, July 26, the preliminary exercises took place. The meeting was called to order by Executive President Charles Kelly, who closed his brief speech by introducing E. C. Fitzgerald, chairman of the local committee, who hoped that every

DELEGATES AND VISITORS AT BERLIN, ONTARIO

delegate would help toward making the convention a success. Mr. Fitzgerald then introduced Mayor C. C. Hahn, who welcomed the delegates and visitors to Berlin. W. A. Crockett, secretary, and A. M. Wickens, treasurer, responded in behalf of the engineers.

After the president had appointed the necessary committees an adjournment was taken until two o'clock in the afternoon.

At the several sessions which followed the business of the convention was disposed of with harmony and despatch.

The reports showed a steady and healthy growth, and the organization is said to be in a prosperous condition.

After some discussion many important changes were made in the constitution, the object being to have one central society in which all the provincial associations will be affiliated.

At the closing meeting on Thursday afternoon the following executive officers were elected: Charles Kelly, past president, of Chatham; J. J. Heeg, president, of Guelph; William Norris, vice-president, of London; A. M. Wickens, treasurer, of Toronto; W. A. Crockell, secretary, of Mt. Hamilton; J. A. Robertson, conductor, of Stratford; H. R. Clark, doorkeeper, of Hamilton. It was decided to hold the next annual meeting at Stratford, during the last week in July.

There were many enjoyable entertainment features. On Tuesday evening a banquet was given at the Walker house, the headquarters of the convention. When the coffee had been served, Mayor Hahn, who acted as toastmaster, introduced Dr. H. G. Lackner, member of the provincial legislature. Mr. Lackner gave a short address, which was followed by a few remarks from Executive President Charles Kelly. The company then adjourned to the Star theater, where in addition to the regular vaudeville performance Charles N. Pische, of Jenkins Brothers, and Jack Armour, of POWER, entertained.

On Wednesday morning there was an automobile ride through the city for the ladies. In the afternoon a visit was made to beautiful Victoria park, where outdoor games of all kinds were indulged in, the ladies taking a prominent part in the sports. Suitable prizes were awarded the winners of each event. Refreshments were served at the close of the festivities.

On Wednesday evening a smoker was held at Victoria hall, at which three very interesting papers were read: "Steam as a Motive Power," by A. M. Wickens; "Considerations Affecting the Choice of an Engine," by A. W. Spotten; "The Saving of Heat Units," by H. L. Peiler. The smoker wound up with an entertainment furnished by the supplymen.

The following firms comprised the exhibitors: Bundy Department, American Radiator Company, Bice Regulator Company, Canadian Manufacturers' Publishing Company, Canadian Fairbanks Company, Canadian Steam Boiler and Equipment Company, Dart Union Company, Dearborn Drug and Chemical Works, Francis Duffy, Garlock Packing Company, Goldie and McCulloch, I. G. Shantz & Co., Jenkins Brothers, Lunkenheimer Company, *Power House*, Piler and MacKenzie, Quaker City Rubber Company, Twin City Oil Company, The Strong, Carlisle and Hammond Company, POWER AND THE ENGINEER.

At a meeting of the Canadian Exhibitors Association held Thursday afternoon the following officers were elected: J. B. Goff, president; E. F. Hetherington, first vice-president; H. L. Peiler, second vice-president; Gordon E. Keith, secretary; D. O. McKinnon, assistant secretary; George O. Fischer, treasurer; W. R. Stanert, chairman of exhibit committee.

Meeting of the Ohio Electric Light Association

The sixteenth annual meeting of this growing and important organization took place July 26, 27 and 28 at "The Breakers" hotel, Cedar Point, O., the charming resort on Lake Erie. E. H. Beil, of Youngstown, vice-president, presided at the opening exercises, at which the convention was heartily welcomed by E. A. Bechstein, of Sandusky, chairman of the committee on general arrangements. Of the papers presented at the meeting one on "Low-pressure Turbines and their Operations," by W. C. Anderson, of Canton, and "Turbine Troubles," by Frank Brosius, of Columbus, were perhaps most interesting to readers of POWER. Mr. Anderson's paper ran in part as follows:

It will be agreed to by all that there is room for improvement in the coal economy of the average electric lighting plant. A coal consumption of 1½ pounds per indicated horsepower-hour, including all auxiliaries, is not unusual in steamship practice. This would be equivalent to 2.6 to 2.75 pounds of coal per kilowatt-hour, making due allowance for the grade of coal usually consumed by electric lighting plants in Ohio. The average coal consumption of the small high-speed lighting plant is about 10 pounds per kilowatt-hour, or nearly four times the amount of coal required to develop an equal amount of power aboardship. The business of supplying electric light is rapidly changing. The cheapness and perfection to which the transmission of power has been developed create an opportunity for large distributing systems, taking advantage of the economies of large units distributing current over a wide area. The small central-station plant with its inefficient means of producing electric power is, therefore, likely to be forced by public sentiment to meet rates prevailing in another territory, although such rates may be below the cost of production under its unfavorable circumstances. We must, therefore, consider in discussing how to improve the coal economy of our plants everything which bears on the situation. To discard the investment already made in generating apparatus for the adoption of more economical equipment of a later type is difficult to justify, even in view of the reduction in operating expenses likely to be realized. We are, therefore, exceptionally interested in any improvement in current-generating equipment that will harmonize with investments already made.

The low-pressure turbine is a piece of apparatus of comparatively late development that fully conforms to this requirement. The steam turbine is an apparatus that has gained a reputation for economy by using economically energy that it is impossible for the steam engine to extract from steam. Over higher ranges of pressure, i.e., from say 200 pounds to atmospheric pressure, the steam turbine is ordinarily less economical than the steam engine. It is only at pressures below the atmosphere that the steam turbine gets its greatest reputation for economy. The most economical unit for the production of power by steam is a combination of high-pressure engine and low-pressure turbine. In the plant already operating its engines condensing, any increase in capacity may be met by installing a steam turbine, either a straight high-pressure, a straight low-pressure or a mixed-pressure unit. The desirability of either one of these three units is an engineering question regarding which no general rule can be laid down. Each problem must be worked out according to the condition prevailing.

For the noncondensing plant many other problems must be met and solved. Speaking generally (from the standpoint of central-station service), the noncondensing plant exhausting into the atmosphere is likely to have a short life. The difference in economy between this kind of a plant and the plant of the average small manufacturer is too small to make profitable the sale of electric power to customers using any considerable quantity of power. The margin between the cost of power to the central station so equipped and a plant on the premises is too narrow to pay the expenses of distributing the current. A noncondensing plant therefore must, to survive, either find a market for its exhaust steam or operate condensing. If condensing water is available the low-pressure turbine offers an almost perfect solution.

Continuing, the paper brought out the flexibility of such a system in the plant of the Canton Electric Company. The installation was primarily a noncondensing-engine plant and at a later date a standard high-pressure 500-kilowatt turbine was installed, using condenser water from a well on the premises. In addition to operating in part condensing, the plant

also includes an exhaust-steam heating system taking steam from the compound noncondensing engines during the winter months. The atmospheric connection to the turbine is, further, connected to the exhaust line, the steam used in this way being expanded in the lower stages of the machine.

During certain hours of the day and depending on weather conditions, there is either a surplus of exhaust steam or a shortage, and to regulate the heating pressure and take advantage of every pound of steam generated by the boilers, the turbine is floated on the line all the time, taking all the exhaust steam from the reciprocating engines that is not required for supplying the heating system or heating the feed water, thus utilizing, during a greater part of the time, steam that otherwise would be wasted, and increasing the output without additional expense at the coal pile. From midnight till morning in very cold weather or during such other hours that the load is lightest and the supply of exhaust least, the turbine is operated noncondensing in whole or in part. The regulation is altogether by electrical load, the turbine and engines feeding into the same system. This flexible arrangement is stated as highly satisfactory and insures excellent economy at all times.

Mr. Brosius' paper dealt with the minor troubles with which the operating engineer has to contend in turbine operation. In reference to the step bearing the paper stated that in the early days of the vertical machine the probability of the loss of the step was considered a serious thing, but now is not considered of more consequence than hot cranks on reciprocating engines of the high-speed type. A reserve-pump system was advocated, such as is in use at the Columbus Railway and Light Company. Here a Worthington hydraulic steam pump is so connected up as immediately to boost the pressure on the steps in case of trouble with the motor-driven pumps. A Williams pump regulator is in the line to the steps, set about five pounds lower than the pressure regularly carried on the step bearings. In case either motor-driven oil pump should drop the pressure the steam pump immediately picks it up. This system has operated perfectly since installation and is much cheaper than the accumulator system, though it requires more attention to keep in running order.

The effect of superheated steam on pipes and fittings was also discussed in this paper, the conclusion being that it is necessary to use steel castings to be on the safe side. An illustration of the effect of superheated steam on different grades of cast iron was shown by the records of two Corliss engines in the plant of the Columbus Railway and Light Company. These engines were required to use superheated steam which had been put in to operate the turbines later installed.

Exactly the same attention was given to each engine, the amount of superheat and lubrication being the same in each case. No. 2 engine cylinders were entirely uninjured by the superheat, while those of No. 3 were badly worn. The deduction is drawn that superheated steam had nothing to do with the wearing in No. 3 cylinder, but that the quality of the iron was decidedly different than that in the other engine, this emphasizing the importance of high quality in any installation where superheat is to be used.

A paper entitled "Motors for Single-phase Circuits as They Are Today," by Prof. F. C. Caldwell, of Ohio State University, contained much condensed information on this type of motor, of which it said in part:

There are six more or less distinct types of motors which can be operated on single-phase current. They may be termed shunt, series, simple induction, split-phase induction, simple repulsion and repulsion induction. The shunt single-phase is easily disposed of. Since a direct-current motor will run forward no matter in which direction the current is supplied, it would continue to run if the current were rapidly reversed or if an alternating current were substituted. Differing reactance of the armature and field, however, introduce difficulties in practical operation and it seems unlikely that any extended development of this type will occur.

In the series motor, the armature and field being in series, there can be no difference in the phase of the currents. The fact that this is distinctly a railway motor and that its application on central-station power circuits is limited would not justify here an extended discussion of its characteristics. Suffice it to say that it has practically the same qualities as the series direct-current motor, though usually slightly less desirable in point of efficiency, weight and cost.

Next come the various induction types, which in the form of constant-speed stationary motors are of the greatest interest to central-station operators. In the simple single-phase induction motor we have the revolving field of the two-phase motor, but here its production is more difficult to understand. The alternating field produced by the magnetizing coils must combine with another field at right angles to it to give the necessary revolving field, but how is the other field produced? Just as in the direct-current machine we have the cross ampere turns and cross flux of the armature, so in the single-phase motor the currents set up in the rotor by the movement of its conductors through the alternating field set up a cross field, also alternating, and at right angles to the main field. We thus have the two alternating fields at right angles to each other, which are needed to produce the rotating field; but it remains to be shown that they are 90 degrees apart in phase as well as in space. This is easily understood if we remember that the rotor is an induction circuit of very low resistance and that consequently the current produced by an alternating electromotive force applied to it must lag nearly 90 degrees behind the voltage. Thus it follows that the magnetic field will be in phase with the current, will be 90 degrees behind the electromotive force in phase, and consequently 90 degrees behind the main field. We have thus the two requisites necessary for a revolving field and thus the single-phase induction motor becomes as simple in its operation as the polyphase.

The repulsion type has next to be considered. This has a simple one-circuit alternating field, but the rotor is wound like a direct-current machine and has a commutator. The brushes, however, are short circuited by a copper bar. To understand this type of machine consider a two-pole machine with the poles horizontal and the brushes set opposite each other under the middle of the poles. Then the rotor winding will act like the secondary winding of a transformer and the electromotive force set up in it will be in opposite directions at the top and bottom of the rotor. Thus a current will flow through the brushes just as in a direct-current machine. However, since the current will be in opposite directions on each side of a brush, that is, under each half of a pole face, the pull under the pole will be half in one way and half in the other and there will thus be no motion.

On the other hand, if we put the brushes vertical or midway between the poles, we shall have no current, since then the electromotive force will be in opposite directions in the two halves of the winding, and there will be no current and hence no motion. If, however, the brushes are set somewhat off from this position, the balance of voltage will be upset and current will begin to flow. Further, this current flowing under the poles will react with the field and a pull will result. Here it is to be noticed that this will occur regardless of whether the rotor is moving or stationary; hence such a motor will start itself and pull a load. This type has in general the characteristics of a direct-current series motor and in its simple form is generally unsuited to stationary requirements, though it is used by some makers as a variable-speed motor. The principle, however, is very useful in starting in connection with motors that operate as simple induction motors after attaining speed, this being accomplished by using a mechanical device with centrifugal-governor weights arranged so as to short circuit the commutator and usually lift the brushes after a predetermined speed is reached.

There remains a special type of repulsion motor or repulsion-induction motor. In this motor, besides the two short-

circuited brushes of the ordinary repulsion type, there are two others, also spaced 180 electrical degrees apart and 90 degrees from the first set. The circuit by which these brushes are connected together, and which is called the compensating circuit, passes through a portion of each of the main field coils, so that a part of the voltage applied to the machine is impressed upon this part of the rotor circuit. Thus two circuits through the armature are established, the energy circuit through the short-circuited brushes and the compensating circuit through the other. By properly designing these coils, characteristics are obtained which give a very satisfactory motor. Further, by use of resistances in the compensating circuit an adjustable-speed motor is obtained, having the characteristics of a shunt direct-current motor regulated by resistances in the armature circuit. A notable characteristic of this motor is the high power factor of 96 to 99½ per cent. Thus the current required for a given load is considerably smaller than with other types.

At the close of the meeting, which was the most successful in the history of the organization, the following officers were elected: E. H. Beil, of Youngstown, president; W. O. Anderson, of Canton, vice-president; and D. L. Gaskill, of Greenville, secretary-treasurer, the latter being reëlected. Cedar Point was chosen as the place of next meeting.

New President for Westinghouse Company

On July 29, George Westinghouse was deposed from the presidency of the Westinghouse Electric and Manufacturing Company. It will be remembered that in the panic of 1907 the Westinghouse Company went into the hands of a receiver and when it was rescued by its banking creditors and reorganized fourteen months later, the direction of the company's policies was largely left in the hands of the chairman of the board, Robert Mather, who was formerly head of the Rock Island system and has represented the bankers. Friction between the organizer of the company and the chairman of the board is given as the reason for the removal of Mr. Westinghouse.

Edwin F. Atkins, of the Boston firm of E. Atkins and Co., was elected to succeed Mr. Westinghouse as president, but it is reported that the choice is only temporary, and it is believed that E. M. Herr, long associated with the Westinghouse Company and a vice-president since the company's financial troubles, will be the eventual head of the company. The new president, Mr. Atkins, has been a member of the board of directors since the company's organization and it is understood that he accepted the presidency with the distinct understanding that he was to hold office only until a permanent successor should be chosen.

At the same meeting the other retiring officers were reëlected and additional officers were elected, including G. W. Hebard and H. D. Shute, who were named acting vice-presidents.

Ex-president Westinghouse is president of the French, Italian and Russian Westinghouse companies and chairman of the board of the English company. He is also president of the Westinghouse Air-Brake Company, the Westinghouse Brake Company, Ltd., of London, the Westinghouse Lamp Company and the Westinghouse Machine Company. There are eighteen American and foreign companies which bear his name, and the stock capitalization of the American companies organized to exploit his inventions totals close to $100,000,000.

SOCIETY NOTES

A joint excursion of the American Societies of Civil and Mechanical Engineers to Panama is talked of for some time in March.

On Sunday, July 31, the members of Rhode Island Association No. 2, National Association of Stationary Engineers, held their annual outing and field-day at Palace Gardens, Narragansett bay. Out of town guests were given breakfast at the Narragansett hotel. At eleven o'clock a light lunch was served at the pavilion, after which the usual base-ball contest between the supplymen's and the local engineers' nines started. Promptly at two o'clock the game was stopped by the umpire, who announced that "Dinner is being served." Members and guests to the number of 275 filed into the dining shed and sat down to a perfectly cooked "shore dinner." After every appetite was satisfied the crowd gathered in the concert hall, where a musical and recitative program was furnished by the "Bunch." Brief speeches were made by National President Reynolds, Massachusetts State President Fuch, Massachusetts State Deputy Kearney, New York State Deputy Coe and J. D. Taylor, secretary-treasurer of the life and accident department. All who attended were presented with white silk souvenir badges, from the lower end of which was suspended in a gilt setting the photograph of Thomas P. Burke.

On July 14, President Taft withdrew several more millions of acres of coal lands in different States of the West, bringing the total of coal-land withdrawals made by him up to the enormous total of 71,518,588 acres. Something like half of this amount are new withdrawals. The areas covered are in several different States.

M. E.'s en Route for England

The steamer "Celtic" of the White Star line, sailing from New York on July 16, carried 148 members of the American Society of Mechanical Engineers and their families en route to accept the invitation of the British Institution of Mechanical Engineers to take part in their summer meeting at Birmingham and London. One hundred others had gone by earlier steamers or other routes.

With such a party an enjoyable voyage would have been assured even under a less solicitous administration and less propitious weather conditions; but with everybody connected with the boat in thorough sympathy with the occasion, and a sea which even the unaccustomed would have been willing to see a little more strenuous, the trip was one which will be memorable for opportunity and for enjoyment to those who were privileged to take part in it.

On Monday evening a reception was held by the officers and past presidents of the society, and for the first time in the history of the line the officers of the ship assisted in receiving.

On Tuesday evening Past President W. R. Warner delivered a lecture illustrated with lantern slides upon astronomy.

For Wednesday evening a musicale was arranged, most of the numbers of which were furnished by members of the party.

On Thursday evening Past President John R. Freeman gave an illustrated lecture upon the Panama canal.

On Friday evening there was a moonlight dance upon the deck. On Friday afternoon numerous amusing contests were carried on upon deck and the prizes to the winners of these as well as of the tournament games were awarded on Saturday evening. Presentations to Captain A Hamilton and Chief Engineer C. C. Lapsley, R. N. R., were made earlier in the day.

At this posting (Saturday night) we are nearing Queenstown, and expect to reach Liverpool ahead of the schedule.

BOOKS RECEIVED

WORK, WAGES AND PROFITS. By H. L. Gantt. *The Engineering Magazine*, New York. Cloth; 194 pages, 4¾x 7½ inches. Price, $2.

STEAM TURBINES. By Walter S. Leland. American School of Correspondence, Chicago. Cloth; 135 pages, 6½x 9¾ inches; 99 illustrations; indexed. Price, $1.

ENGINEERING CHEMISTRY. By Thomas B. Stillman, Chemical Publishing Company, Easton. Cloth; 744 pages, 5½ x9 inches; 174 illustrations; indexed. Price, $5.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power and the Engineer.

THE Singer Building in New York is the tallest in the world.

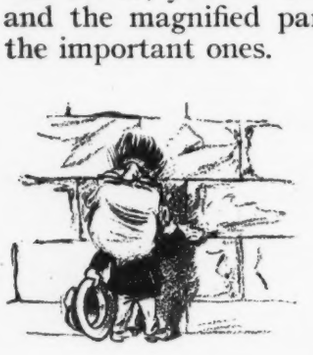
We say that today, reserving the right to retract it tomorrow.

This is an age of gone today, here tomorrow, in building enterprise. You never can tell. As Mr. Dooley puts it, "'Tis a wonderful time we're livin' in, Hinnessy. Today they build a 20-story skyscraper and t'morrow they tear ut down t' make way fer a modern buildin'."

Today, to the best of our knowledge, the Singer Building is "it."

It rears its massive height, floor after floor, culminating in the tower that seems to pierce the sky. It makes its contemporaries look like six nickels and the Tower of Babel a pigmy.

Stand a few blocks away from it and you see it in all its majesty and impressiveness. Get close alongside of it and your cramped view reveals only a pile of stone. Your view-point is all wrong; it's distorted, ou f focus. You are too close to your object; you only half see it; you see too much of some of it—and the magnified parts are not necessarily the important ones.



A lot of advertisers and readers of advertising are in the position of the man who stands against the Singer Building, looks up and thinks he sees it all. They are too close.

So many advertisers assume that the reader knows all about their product anyway, and that it is a waste of space and words to tell him anything in their advertisements.

So many readers of advertisements are unwilling to believe that anybody can tell them any way to save time or money in *their* business. They resent the thought.

And, therefore, many advertisements say nothing or exaggerate the unimportant and many readers close their eyes and minds to arguments and appeals that might prove of untold benefit to them.

The remedy? Get a better view-point.

Stand off a little way, get up on a hill and look at the situation.

Let the advertiser put himself into the shoes of the man he wants to use his goods. Remember that the possible buyer is not interested in the advertiser's age, personal habits or the brand of union suit he wears. The *article*, the *completed* article, that's the thing! *Why* should the possible buyer own it—get the *reasons* into the advertisement. Get them there plain and clear. Stick to words of one syllable, if possible. The average reader is not a walking dictionary, yet we know of one advertiser who describes his product with an adjective that, as he proudly says, the "dictionaries haven't got yet."

Let the reader of advertisements remember that advertised goods must make good or fail utterly. Let him remember that no fake can be successfully advertised continuously. Bear in mind that statements made in advertisements are "on record"—they're part of the contract. The advertiser must back them up. Remember, that any good device for power-plant use was designed to fulfil a need or meet a requirement. You can't tell how close it will come to fitting your case until you investigate thoroughly.

Let both advertiser and buyer get a clearer, better view of what *advertising* is.

It is simply the spreading of worth-while information among those whom the information may benefit and who may benefit the advertiser.

Some folks approach an advertisement as if they are afraid it will bite. The ad-writer is yet to be born who can get any "hypnotic" quality into his "copy." No advertiser can *force* his product on you. He simply lays his case before you and you become judge, jury, court officer and all the rest of 'em.

Advertising is a great *force*. How great, it is hard to estimate. It is for two classes—the buyer and the seller. No seller is benefited by its use any more than are the buyers of his product in the aggregate.

Which is a thought to take to heart next time you're "tempted" to investigate the merits of an advertised article.